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SOME CHEMISTRY OF LIGHT[1]

FROM the dawn of history, chemistry has had much to do with the production of artificial light, and I wish now to recall to your minds a few illustrations. I will not burden your ears with a long story on physics or mechanics of light, but intend treating the subject of artificial light so as to show you that it has always been largely a subject for chemical investigation. I want to impress upon your minds that it is still a most green and fertile field for the chemist. I have tried to arrange a few familiar experiments to illustrate some of the facts touched upon, and it should be borne in mind that I am trying to interest an audience of chemists from widely different fields, rather than to present a chronological record of recent experimental research.

I can not tell just when chemistry was first scientifically applied to a study of artificial light. Most cardinal discoveries are made by accident and observation. The first artificial light was not made by design nor was the first improvement the result of chemical analysis. It is supposed that the first lamps were made from the skulls of animals, in which oil was burned. Herodotus, describing events about three centuries before Christ, says of the Egyptians:

> At the times when they gather together at the city of Sais for their sacrifices, on a certain night they all kindle lamps many in number in the open air round about the houses: now the lamps are saucers full of salt and oil mixed and the wick

[1] Presidential address delivered at the Boston meeting of the American Chemical Society, December 29, 1909.

floats of itself on the surface and this burns during the whole night.

This night was observed all over Egypt by the general lighting of lamps, and these lamps were probably the forerunners of the well-known Greek and Roman lamps of clay and of metal which are so common in our museums.

The candle and lamp were probably invented very much earlier. We know that both lamps and candles were used by the priests of the Jewish temple as early as 900 B.C. The light of those candles and lamps was due, as you know, to particles of carbon heated in a burning gas.

It is not fair to the chemists of our early candle-light to skip the fact that great chemical advances were made while candles were the source of light, and so I touch for a moment upon one of the early applications of chemical knowledge. The fats and waxes first used were greasy and the light was smoky and dull. They were capable of improvement and so the following chemical processes were developed and applied to the fats. They were first treated with lime, to separate the glycerol and produce a calcium soap. This was then treated with sulphuric acid, and the free stearic and palmitic acids separated. These acids were then made into candles and gave a much whiter light than those containing the glycerol ester previously used. Similar applications of chemical principles are probably known to you all in the refining of petroleum. The crude distillate from the rock oil is agitated with sulphuric acid and then washed with a solution of sodium hydroxide. This fact accounts, in considerable degree, for the advance of a number of other chemical processes. An oil refinery usually required the presence of a sulphuric-acid plant in the immediate vicinity, and this often became a source of supply for other new chemical industries.

Very great advances have been made in the use of fats and oils for lighting purposes, but there is so much of greater interest in later discoveries that we will not consider many of them. The distillation of gas from coal or wood in 1739 was a chemical triumph, and a visit to a gas plant still forms one of the main attractions to the young chemist in an elementary course of applied chemistry. The first municipal gas plant was established in London, just about one hundred years ago. The general plan, so apparently simple to us to-day, was at its inception judged impracticable by engineers. In spite of other methods of illumination, the improvements in the making, purification and application of illuminating gas have caused a steady increase in its use. Gas owes its illuminating power to the fact that a part of the carbon in it is heated to incandescence during the combustion of the gas. It must contain, therefore, such carbon compounds as yield a fair excess of carbon, and this knowledge has led to the schemes for the enrichment of gas and for the use of non-luminous water-gas as a base for illuminating gas.

Various schemes were devised in the early part of the nineteenth century for using gas to heat to incandescence, rods or surfaces of lime, zirconia and platinum. This was not at first very successful, owing to imperfect combustion of the gas. The discovery of the Bunsen-burner principle was made a little later. By thus giving a much higher temperature to the gas flame and insuring complete combustion, new impetus was given to this branch, and the development of suitably supported oxide mantles continued for half a century.

Most prominent in this field is the work of Auer von Welsbach. It was a wonderful series of experiments which put the group of rare earth oxides into practical use and started a line of investigation

which is still going on. The Welsbach mantle practically substitutes for the carbon of the simple gas flame another solid in a finely divided shape capable of giving more efficient light. This allows all of the carbon of the gas to contribute to the production of a hotter flame. But more interesting than the mechanical success, to my mind, is the unforeseen or scientifically unexpected discovery of the effect of chemical composition. By experiment it was discovered that the intensity and color of the various mixtures of difficultly fusible oxides at incandescence varied over a wide range. Thus a broad field for unforeseen investigation was opened. The samples of Welsbach mantles which you see before you were kindly loaned to me by Mr. H. S. Miner, of the Welsbach Company, and beautifully illustrate the application of advanced chemical work to this industry. The color and intensity of the light vary in an unexplained manner with slight differences in composition of the mantle. The following are the composition and candle powers of the mantles shown:

CANDLE POWER OF MANTLES, RANGING FROM PURE THORIA TO 10 PER CENT. CERIA

No.	Per Cent. Thoria	Per Cent. Ceria	Candle Power
367	100.00	0.00	7
368	99.75	0.25	56
369	99.50	0.50	77
370	99.25	0.75	85
371	99.00	1.00	88
372	98.50	1.50	79
373	98.00	2.00	75
374	97.00	3.00	65
375	95.00	5.00	44
376	90.00	10.00	20
69	La, Zr, Ce Oxides,		30

The methods of making present mantles were also a part of Dr. Auer's contribution to the art. Suitably woven fabrics are dipped into solutions of the rare earth salts; these are dried and the organic matter burned out, leaving a structure of the metal oxides.

The pure thoria gives a relatively poor light. The addition of the ceria, up to a certain amount, increases the light. This added component is called the "excitant," and as the cause for this beneficial action of the excitant is not known, it is possible that further discoveries along this line will yet be made. There is hardly a prettier field for chemical speculation than is disclosed by the data on these light efficiencies. For some unknown reason, the change in composition by as little as one per cent. varies the luminosity over tenfold, and yet more than one per cent. of the excitant (ceria) reduces the light. Besides the temptation to speculation, such disclosures of nature encourage us to put greater trust in the value of new experiments, even when accumulated knowledge does not yield a blazed trail for the pioneer. By giving a discovery a name and attaching to it a mind-quieting theory, we are apt to close avenues of advance. Calling this small amount of ceria an "excitant" and guessing how it operates is directly harmful unless our guess suggests trial of other substances.

One of the explanations proposed to cover the action of the ceria ought to be mentioned, because it involves catalysis. This is a term without which no chemical lecture is complete. Some think that the special mantle mixture causes a more rapid and localized combustion, and therefore higher temperature, by condensation of gas in its material. Others think that this particular mixture permits of especially easy and rapid oxidation and reduction of its metal oxides themselves in the burning gas mixture. The power which catalyzers have of existing in two or more states of oxidation seems to apply also to the ceria of the Welsbach mantle. Whatever the truth

may be, it has been shown by Swinton[2] that when similar oxide mantles are heated to incandescence by cathode rays in vacuo, the presence of one per cent. ceria produces only a very small increase in the luminosity of thoria. It is interesting to note that in the gas flame *pure ceria* gives about the same light as *pure thoria*, while in the cathode rays of the Crookes tube, with conditions under which ceria gives almost no light, pure thoria gives an intense white light. These facts, which are still unexplained, illustrate how little is understood in this field.

I will merely refer to the fact that vapors of gasoline, kerosene, alcohol, etc., are also now used in conjunction with the Welsbach mantles. The field of acetylene I must also omit with a mere reference to the fact that the manufacture of calcium carbide was a chemical discovery, and the action of water upon it, producing the brilliantly-burning acetylene gas, was another.

Turning now to electrical methods of generating light, we find the chemist early at work. Sir Humphry Davy and others, at the dawn of the nineteenth century, showed the possibilities which since that time have been developed into our various types of incandescent and arc lamps. We naturally attach Mr. Edison's name to the development of the carbon incandescent lamp, because it was through his indefatigable efforts that a practicable lamp and illuminating system were both developed. It had long been known that platinum, heated by the current, gave a fair light, but it melted too easily. A truly enormous amount of work was done in attempts to raise the melting-point of the platinum, and the effect of occluded gases, of annealing, of crystalline condition, etc., were most carefully studied, but the results were unsatisfactory. He was therefore led to the element carbon as the next most promising conductor of high melting-point. Edison's persistent and finally successful attempts to get a dense, strong, practical filament of pure carbon for his lamps is one of the most encouraging lessons to the chemist of to-day. This history needs to be read in the light of the knowledge of carbon at that time and the severe requirements of a commercially useful carbon filament. It illustrates the value of continued effort when it is based on knowledge or sound reasoning. The search was not the groping in the dark that some of us have imagined, but was a resourceful search for the most satisfactory, among a multitude of possible materials. From our point of view, all subsequent changes in choice of material for incandescent lamp filaments have been dictated by the knowledge that high melting-point and low vapor tension were the first requirements. If you will consult the curve of the *melting-points* of all the *elements*, as plotted against their *atomic weights*, you will see at once that the desired property of high melting-point is a periodic function of the atomic weight. And it is this fact, which was independently disclosed as a general law by Meyer and Mendeljeff, in 1869, that has aided in the selection of all the new materials for this use. You will notice that the peaks of the curves are occupied by such elements as carbon, tantalum, tungsten, osmium, etc., which are all lamp materials.

A study of the laws of *radiation* also soon played a part in incandescent lamp work. The early rough and black filament of bamboo was first replaced by a polished black carbon filament, and later by one which had a bright, silver-gray coat of graphite. A black body at any temperature radiates the maximum possible energy in all wave-lengths. Heated to incandescence, it will *radiate more invisible and*

[2] *Proc. Roy. Soc.*, 65, 115.

useless ***infra-red rays than any other*** opaque material at the same temperature. A polished metal is therefore a more efficient light source than the same metal with a black, or even rough surface. This is derived from Kirchhoff's law of radiation and absorption, which was early established.

It may seem like penetrating too far into details to consider for a moment the changes in structure and surface which the carbon filament of our incandescent lamps has undergone, but the development of such an apparently closed problem is instructive because it has yielded to such simple methods of attack. The core, or body, of the carbon filament of to-day is made by some one of the processes based on dissolving and reprecipitating cellulose, which are used in artificial silk manufacture. The cellulose solution is squirted through a die into a liquid which hardens it into dense fibers. These cellulose fibers are then carbonized by being heated, out of contact with the air, at as high a temperature as possible with gas furnaces. All of this is also merely the application of chemistry which was first worked out in some of the German chemical laboratories. This plain carbon filament (the result of this simple process), which might have been satisfactory in the early days, would be nowadays useless in a lamp, as its practical life is only about 100 hours at 3 watts per candle. In a subsequent process of manufacture it is therefore covered with a steel gray coating of graphite, which greatly improves the light emitting power. This coat is produced by heating the filament in an atmosphere of benzene or similar hydrocarbons. The electric current which heats the filament is of such an intensity that the decomposition of the hydrocarbon produces a smooth, dense deposit of graphite. With this graphite-coat the filament now burns about 500 hours. But the simple graphite coat can itself be improved. It is improved by being subjected, for a few moments, in the electric furnace, to a temperature of about 3,500°, so that the life now becomes about 1,500 hours under the same operating conditions as before. The product of this treatment is known as the metallized filament, because its temperature coefficient of resistance is by this last step made similar to that of the metals.

A case is shown on the table which contains illustrations of the carbon incandescent lamp manufacture in the shape of cellulose solution, squirted cellulose fiber, carbonized fiber, etc.

Among the incandescent lamps which are before you I have one containing a platinum wire filament. You will see, as I turn on the current, that the intensity of its light is not very great, even when the current is sufficient to melt the wire. A much greater luminosity is produced by a plain carbon filament, and a still greater by the graphite-coated and metallized carbon, before they are destroyed. In the case of carbon, the useful life of the lamp depends much more on the vaporization of the material than on its melting-point, and these lamps, as shown, will operate for a short time at very much greater efficiencies or higher temperatures than is possible when a practical length of life is considered. Thus, besides the physical effect of surface quality, we have evidence of differences in the vapor pressure of different kinds of carbon. It looks as though carbonized organic matter yielded a carbon of much greater vapor pressure for given temperature than graphite, and that even graphite and metallized graphite are of quite distinctly different vapor pressures at high temperatures. It may be interesting to note here that if the carbon filament could withstand for 500 hours the maxi-

mum temperature which it withstands for a few moments, as shown in the experiments, then the cost of operating incandescent lamps could be reduced to nearly a fifth of the present cost.

It was discovered by Auer von Welsbach that the metal osmium could be made into a filament, though it could not be drawn as a wire. The osmium lamp was the first of the recent trio of metallic filament incandescent lamps. The tantalum lamp, in which another high melting-point metal replaces the superior but more expensive osmium, has been in use six or eight years. This surpasses the carbon in its action, and on running up to its melting-point it shows still brighter light than carbon. More recently the tungsten filament lamp has started to displace both lamps. At present this is the element which withstands the highest temperature without melting or vaporizing, and on being forced to its highest efficiency in a lamp you see that it reaches higher luminosity and that there is a similarity to carbon and tantalum in that an enormously greater efficiency may be produced for a very short time than can be utilized for a suitable length of life. The inherent changes at these temperatures, distillation or whatever they are, quickly destroy the lamp. The lamp will burn an appreciable time at an efficiency fifteen times as great as that of the common operating carbon incandescent lamp (at 3 watts per candle). In other words, light may be produced for a short time at an energy-cost one fifteenth of common practise, so that there is still a great field for further investigation directed towards merely making stationary those changing conditions which exist in the burning lamp.

While it is generally true that the light given by a heated body increases very rapidly with rise of temperature above 600°, the regularity of the phenomenon is commonly over-estimated. A certain simple law covering the relation between the temperature and the light emitted, has been found to apply to what we have called a black body. This so-called Stefan-Boltzmann law states that "the total intensity of emission of a black body is proportional to the fourth power of the absolute temperature." There are, however, very few real black bodies in the sense of the law. The total emission from a hole in the wall of a heated sphere has been shown experimentally to follow the law rigidly, but most actual forms and sources of illumination do not. Most practical sources of artificial light are more efficient light producers than the simple law requires. This may be said to be due to the fact that these substances have characteristic powers of emitting relatively more useful energy as light than energy of longer wave-length (or heat rays). Most substances show a power of selective emission and we might say that an untried substance, heated to a temperature where it should be luminous, could exhibit almost any conceivable light effect. It is still less possible to predetermine the proportionality between luminous and non-luminous emission. A simple illustration will serve to make this clear: if a piece of glass be heated to 600°, it does not emit light. If some powder such as zirconia or thoria be sprinkled upon it, light is emitted and the proportion of light at the same temperature will depend upon the composition of the powder. Coblentz has shown, both for the Auer mantle and for the Nernst glower, that the emission spectra are really series emission bands in that portion of the energy curve which represents the larger part of the emitted energy. This is in the invisible infra-red part, and so the laws which govern the emission at a given temperature depend upon the chemical composition of the radiant source. Sili-

cates, oxides, etc., show characteristic emission bands.

One of the most attractive fields of artificial light production has long been that of luminous gases or vapors. It has seemed as though this ought to be a most satisfactory method. The so-called Geissler tubes in which light is produced by the electrical discharge through gases at low pressure are familiar to all. The distribution of the energy emitted from gases is still further removed than that of solids from the laws of a black body, and a large proportion of the total electrical energy supplied to a rarefied gas may be emitted as lines and bands which are within the range of the visible spectrum. These lines, under definite conditions of pressure, etc., are characteristic of the different elements and compounds. The best known attempts to utilize this principle are the Moore system of lighting, in which long tubes of luminous gas are employed, and the mercury lamps, which, while more flexible on account of size, are still objectionable because of the color of the light. A simple form of mercury arc is shown.

It is rather interesting that the efficiencies of all of these various sources of electric light are not nearly so widely different as one would expect from a consideration of the widely divergent methods of light production employed.

From the light of a vapor or gas to that of an open arc is not a wide step, but the conditions in the arc are apparently quite complex and there is a great deal of room for interesting speculation in the phenomena of an arc. Briefly, there are two kinds of arcs to be considered in lighting. One has been in use for a century, the other for a few years only. The first is the successor to Sir Humphry Davy's historical arc between charcoal points. In this kind of arc the current path itself is hardly luminous and the light of the lamp is that given by the heated electrodes. In case of direct current it is the anode, or positive electrode, which gets the hotter and gives far the greater part of the light. In the carbon arc shown, it will readily be seen that the light is emitted by the heated solid carbon of one electrode. This gives a steady source of light, but is not so efficient as an arc in which material in the arc stream itself is the source of light. The arc may be made to play upon rare earth oxides, and these, being heated to incandescence, increase the luminosity, but this has not proved useful. The more common way is to introduce into the carbon electrode certain salts which volatilize into the arc and give a luminous effect. Here cerium fluoride, calcium fluoride, etc., are used, and the color of the arc, just as in the case of gas mantles, may be varied by varying the composition of the electrodes. This is seen in the arc from the carbon electrodes containing such salts.

I have arranged several different kinds of arcs, and before each is a magnifying lens, to throw the image of the arc upon a screen. This permits our seeing the phenomena of the arcs and observing the characteristics of each. The very essential differences between the plain carbon arc and the luminous or flaming arc is readily noticed. In the latter case the greater part of the light is due to the incandescent metallic vapors in the space between the electrodes. Substitution of one chemical for another in such flaming arc electrodes has covered quite a wide range of chemical investigation. Salts are chosen which give the greatest luminosity without causing the formation of too much ash or slag. Some compounds of calcium, for example, are practicable, while others are not, though all of these would, under suitable conditions, yield the calcium spectrum.

If such salts as calcium fluoride were conductors at ordinary temperature, useful electrodes for flame arcs would probably be made from them. Such conducting materials as iron oxide, carbides, etc., have been used for flame arc electrodes, and a great many of the so-called magnetite arcs are now in use. The electrodes in this case are largely magnetic oxide of iron, with such other ingredients as titanium and chromium oxides, to increase the intensity of light, to raise the melting-point of the mixture, etc.

As will be seen from observing this arc, the light is very white and intense and is generated by the heated vapors of the arc proper. A great many modifications of this arc principle are possible. Titanium carbide and similar substances give characteristic arcs, and some of them are very intense and efficient. For purposes of comparison, I have added to this illustrating experiment an arc of titanium carbide and one of copper.

THE NERNST LAMP

A distinct species of electric incandescent lamp is that invented about ten years ago by the well-known physical chemist, Professor Nernst. This employs for filaments a class of bodies which are not electrical conductors at all at ordinary temperatures, and which, at their burning temperatures, do not conduct the current as metals and carbon, but as a solution does. This kind of conductivity, the electrolytic, involves electrochemical decomposition at the electrodes, and in the case of the Nernst filaments these otherwise destructive reactions are rendered harmless by the continual oxidizing action of the air. For this reason this type of lamp will not burn in vacuo. For its most perfect utility the principle of the Nernst lamp seems to require a mixture of oxides, because a single one is not so good a conductor nor so luminous. It uses oxides because these are the most stable compounds known, and it uses the rare earth oxides because they have higher melting-point than other oxides. As the efficiency very rapidly rises with temperature, there is a great advantage in using the most infusible base possible. For that reason, zirconia, thoria, etc., are usually employed.

In this lamp a rod or filament of an oxide mixture, much like those used in Welsbach mantles, is heated by the current externally applied until it reaches a temperature at which it becomes a good conductor itself. Here again the peculiar laws of light radiation are illustrated, the light emitted at a given temperature being determined by the nature of the substance. Just as the pure thoria gives a poor light compared to the mixture with one per cent. ceria, so a pure zirconia rod, heated by the current, gives much less light than a rod containing a little thoria, ceria or similar oxide. Work done by Coblentz on the energy-emission of such rods shows the emission spectra, at least in the infra-red, to vary with the nature of the substance. In general, the spectra are not continuous like the spectra of metals and black bodies, but seem to occupy an intermediate position between these and luminous gases, which we know have usually distinct line spectra.

This recalls the subject of selective emission. Coblentz has shown selective emission in the long wave-lengths for a Nernst glower. This is shown in comparison with the emission of a black body, in curve No. 1. The two sources, when compared at the temperatures where they exhibit the same wave-length for maximum emission, differ very considerably in emission in the infra-red, the black body giving more energy at the blue end and less at the red end of the spectrum.

This is still more noticeable in the curves

for such substances as porcelain, magnesia and glass, as shown by Coblentz's curves (Fig. 2).

The curves of wave-length and radiant energy which are shown are, with slight

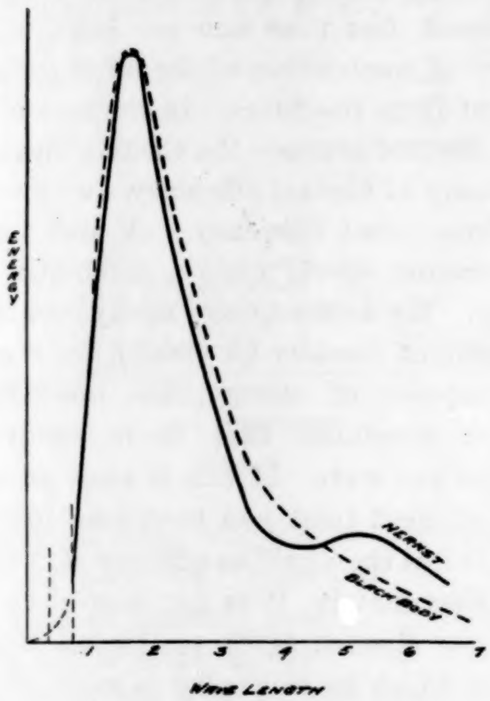

FIG. 1

modifications, taken from work of Lummer and Pringsheim and of Dr. Coblentz. The

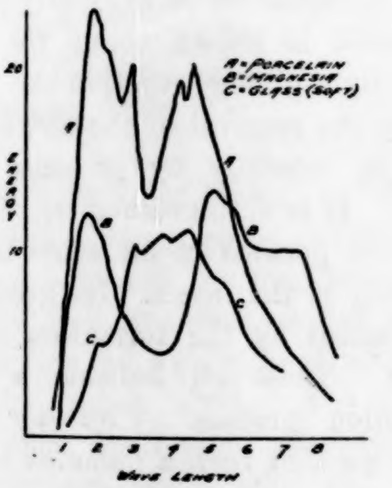

FIG. 2

curve for the ideal, or black body radiator, gives a picture of the total energy and its distribution over the different wave-lengths. It is the peculiarity of the black body to radiate more energy of any given wave-length than does any other body at the same temperature. Therefore, in case of all substances acting as thermal radiators, the black body will always give the greatest brilliancy. Since this body at the same time radiates a maximum in *all* wave-lengths, it will be surpassed in light *effi-*

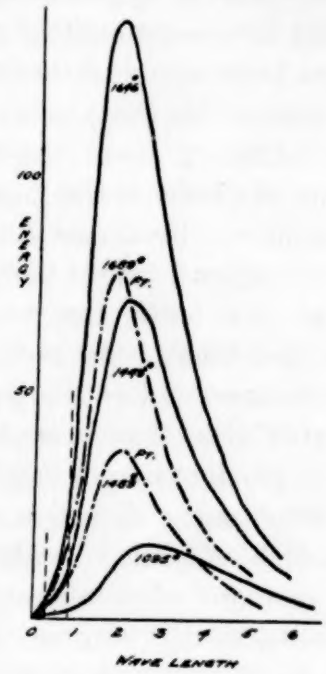

FIG. 3

ciency by any substance which is a relatively poor radiator in the invisible or non-luminous part of the spectrum.

In the energy curves shown it is to be noticed that the visible part of the energy is practically only that between 0.4 and 0.8 thousandths of a millimeter. Consider the black lines in Fig. 3 for a moment. These show the emission of a black body at centigrade temperatures noted on the curves. Evidently the energy emitted rises very rapidly with the temperature; *i. e.*, as the fourth power of the absolute temperature. It will be noted also that the point of maximum energy or wave-length corresponding to maximum energy shifts gradually to-

wards the left, or towards the visible wave-lengths.

It is this rapid shifting of the position of maximum energy which makes the search for substances which can withstand even only slightly higher temperatures of such great interest.

The curves for the black body and for platinum (dotted lines) are not greatly different in general appearance, but the total amount of energy emitted at a given temperature from the black body is shown to be more than for the platinum, and it can be seen that at about the same temperature the platinum is the more economical light source. Professor Lummer has said that at red heat, bright platinum does not radiate *one tenth* the total energy which the ideal black body radiates at the same temperature, and at the highest temperature still less than one half. The deviation of platinum from the black body law is a step in the direction of getting improved light-efficiency without corresponding increase of temperature. This method is practically without limit in its extension, for there seems to be no limit to the forms of energy curves which different substances may possess. The curves are apparently determined not only by physical state, but also by chemical composition of the emitting substance.

You see before you a vacuum incandescent lamp which contains a ribbon of platinum in the shape of a loop. While the section of the platinum is the same throughout, one half of the loop is blackened by depositing a little platinum black upon it. This greatly affects the light efficiency as shown. The blackened portion, being more nearly a black body, radiates at each temperature relatively more energy of long wave-length (*i. e.*, heat) than the bright portion. So for about equal total energy radiated the ribbon radiates less as light from the blackened surface.

In the production of artificial light, the tendency will always be in the direction of increasing the practical efficiency, *i. e.*, reducing the cost of light. We have seen that there is still much room for this. In the case of the kerosene oil lamp we know that much less than one per cent. of the energy of combustion of the oil is radiated as light from the flame. In the case of the most efficient source—the electric incandescent lamp at *highest* efficiency—we are still far from ideal efficiency. A still higher temperature would yield a yet higher efficiency. We do not know exactly how much light might possibly be yielded for a given consumption of energy, but one experimenter concludes that it is about ten candles per watt. If this is true, even the most efficient light you have seen this evening is less than half as efficient as it might be. Fortunately, it is not now clear just how the chemist is to realize all the advances which he will make in more efficient lights.

No consideration of this part of the subject is complete without a brief reference to the efficiency of the fire-fly. The source of his illumination is evidently chemical. This much is known about the process:

The light-giving reaction is made to cease by the removal of the air, and to increase in intensity by presence of pure oxygen. It is extinguished in irrespirable gases, but persists in air some time after the death of the insect. Its production is accompanied by the formation of carbon dioxide. These all indicate a chemical combustion process. Professor Langley has shown that such a flame as the candle produces several hundred times as much useless heat as the total radiation of the fire-fly for equal luminosity. In other words, the fire-fly is the most efficient light source known. This is illustrated by the energy distribution curves from several

light sources taken from Professor Langley's work (Fig. 4). The difficulties attendant upon the accurate determination of the curve for the fire-fly are so great that we ought not to expect very great accuracy in this case. These curves, which in each case refer to the energy after pass-

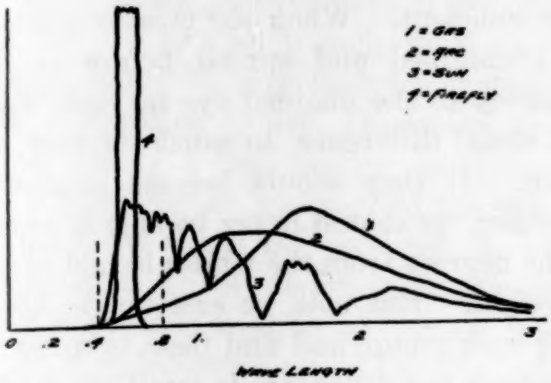

FIG. 4

ing through glass, which cuts off energy of long wave-lengths, represent the same quantities of radiant energy. While the sun is much more efficient than the gas flame or carbon arc, it still presents far the largest part of its energy in the invisible long wave-lengths (above 0.8), while the fire-fly seems to have its radiant energy confined to a narrow part of the visible spectrum.

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RACIAL DIFFERENCES IN MENTAL TRAITS[1]

ONE of the most agreeable and satisfying experiences afforded by intellectual pursuits comes from the discovery of a clean-cut distinction between things which are superficially much alike. The esthetic value of such distinctions may even outweigh their intellectual value and lead to sharp lines and antitheses where the only difference that exists is one of degree. A favorite opportunity for this form of intellectual exercise and indulgence is afforded by the observation of groups of men. The *type* of man composing each group—that is what we should like to find; and we hear much of the "typical" scientist, the typical business man, the typical Englishman or Frenchman, the typical southerner, the typical Bostonian. The type of any group stands as a sort of ideal within the group, and, more or less caricatured, as the butt of the wit of other groups. There is one peculiar fact about these types: you may have to search long for an individual who can be taken as a fair example. And when you have at last found the typical individual, you may be led to ask by what right he stands as the type of the group, if he is a rarity amidst it.

If we would scientifically determine the facts regarding a group of men, we should, no doubt, proceed to examine all the individuals in the group, or at least a fair and honest representation of them. The first fact that meets us when we proceed in this way is that the individuals differ from each other, so that no one can really be selected as representing the whole number. We do find, indeed, when we measure the stature or any other bodily fact, or when we test any native mental capacity, that the members of a natural group are disposed about an average, many of them lying near the average, and few lying far above or far below it; and we thus have the average as a scientific fact regarding the group. But the average does not generally coincide with the type, as previously conceived, nor do the averages of different groups differ so much as the so-called types differ. Moreover, the average is itself very inadequate, since it does not indicate the amount of variation that exists within the group—

[1] Address of the vice-president and chairman of Section H—Anthropology and Psychology—of the American Association for the Advancement of Science, Boston, 1909.

and this is one of the most important facts to be borne in mind in understanding any collection of individuals. It is specially important in comparing different groups of men, since the range of variation within either group is usually much greater than the difference between the averages of the groups. The groups overlap to such an extent that the majority of the individuals composing either group might perfectly well belong to the other.

No doubt statements like this will be readily accepted as far as concerns the different nations belonging to the same race. One could not seriously doubt that the nations of Europe, though they might differ slightly on the average, would so much overlap one another that, except for language and superficial mannerisms, the great majority of the members of one nation might be exchanged with a majority from another nation without altering the characteristics of either. But when we extend our view to all the peoples of the earth, the case would at first appear quite changed. Certainly whites and negroes do not overlap, to any extent, in color of skin, nor negroes and Chinamen in kinkiness of hair, nor Indians and Pygmies in stature. Such specialization of traits is, however, the exception. Whites and negroes, though differing markedly in complexion and hair, overlap very extensively in almost every other trait, as, for example, in stature. Even in brain weight, which would seem a trait of great importance in relation to intelligence and civilization, the overlapping is much more impressive than the difference; since while the brain of negroes averages perhaps two ounces lighter than the brain of Europeans, the range of variation within either race amounts to 25 ounces.

Our inveterate love for types and sharp distinctions is apt to stay with us even after we have become scientific, and vitiate our use of statistics to such an extent that the average becomes a stumbling-block rather than an aid to knowledge. We desire, for example, to compare the brain weights of whites and of negroes. We weigh the brains of a sufficient number of each race—or let us at least assume the number to be sufficient. When our measurements are all obtained and spread before us, they convey to the unaided eye no clear idea of a racial difference, so much do they overlap. If they should become jumbled together, we should never be able to separate the negroes from the whites by aid of brain weight. But now we cast up the average of each group, and find them to differ; and though the difference is small, we straightway seize on it as the important result, and announce that the negro has a smaller brain than the white. We go a step further, and class the white as a large-brained race, the negro as a small-brained. Such transforming of differences of degree into differences of kind, and making antitheses between overlapping groups, partakes not a little of the ludicrous.

We seem to be confronted by a dilemma; for the group as a whole is too unwieldy to grasp, while the average, though convenient, is treacherous. What we should like is some picture or measure of the *distribution* of a given trait throughout the members of a group; and, fortunately, such measures and pictures can be had. Convenient and compact measures of variability are afforded by the science of statistics, and are of no less importance than the average. But still better, because closer to the actual facts, are graphic or tabular pictures of the distribution of the trait, showing the frequency with which it occurs in each degree. The distribution of a trait is for some purposes more important than the average. Let us suppose, for instance,

that two groups were the same in their average mental ability, but that one group showed little variation, all of its members being much alike and of nearly the average intelligence, while the other group showed great variability, ranging between the extremes of idiocy and genius. It is evident that the two groups, though equal on the average, would be very unequal in dealing with a situation which demanded great mental ability. One master mind could supply ideas for the guidance of the group, and his value would far outweigh the load of simpletons which the group must carry.

If groups of men differ in average intelligence, this difference would have an influence on their effectiveness in mental work, and so, no doubt, on their advance in civilization. If groups differ in variability, this would probably have a still greater influence. There is one respect in which groups certainly do differ. They differ in size, and size is an important consideration, even from a purely biological point of view. The more numerous the individuals born into a group, the greater the absolute number of gifted individuals to be expected; and in some respects it is the absolute rather than the relative number of able men that counts. Besides this, the larger the group, the greater the chance of its producing a truly effective genius, just as, in the experiments of Burbank and other breeders, a vast number of plants are grown, in order to increase the chance of sports occurring.

One further consideration of this partly biological, partly statistical, nature should be brought forward before passing from preliminary remarks to the consideration of actual data. When the individuals composing a group are measured or tested in several traits, it is found that those who rank high in one trait do not always rank high in others. On the whole, there is more correspondence than opposition; an individual who ranks well in one trait is rather apt to rank well in others. The correlation, as we say, is positive, but it is far from perfect. The individuals most gifted with ability in war are not altogether the same individuals who are ablest in government, or in art or literature, or in mechanical invention. This fact is not only of importance in reaching a just conception of a group, but it should be considered in comparing different groups. The circumstances surrounding a group call for certain special abilities, and bring to the fore the individuals possessing these abilities, leaving in comparative obscurity those gifted in other directions. Judging the group largely by its prominent individuals, we get the impression that the group is gifted in certain lines, and deficient in others. A nation whose circumstances call for industrial expansion and the exploitation of natural resources gives prominence to those of its members who are successful in these pursuits, and leaves in obscurity many who have native capacity for military leadership. Should war come to such a community, time and bitter experience are often necessary before the leadership can be transferred from the previously eminent men to those obscure and often despised individuals who are capable of doing best service in the new direction. This lack of perfect correlation between various abilities makes it difficult to judge of the capacity of a group of men by casual observation; and we must accordingly discount largely the appearance of specialization of mental traits in different peoples.

All in all, the discovery of true inherent differences between races and peoples is an intricate task, and if we now turn to the psychologist to conduct an examination of different groups, and to inform us regarding their mental differences, we must not

allow him to present a hasty conclusion. His tests must be varied and thorough before we can accept his results as a serious contribution to this difficult subject. The psychologist may as well admit at once that he has little to offer; for, though the "psychology of peoples" has become a familiar phrase, and though books have been written on the subject, actual experimental work has so far been very limited in quantity.

One thing the psychologist can assert with no fear of error. Starting from the various mental processes which are recognized in his text-books, he can assert that each of these processes is within the capabilities of every group of mankind. All have the same senses, the same instincts and emotions. All can remember the past, and imagine objects not present to sense. All discriminate, compare, reason and invent. In all, one impulse can inhibit another, and a distant end can be pursued to the neglect of present incitations. Statements to the contrary, denying to the savage powers of reasoning, or abstraction, or inhibition, or foresight, can be dismissed at once. If the savage differs in these respects from the civilized man, the difference is one of degree, and consistent with considerable overlapping of savage and civilized individuals. The difference of degree calls for quantitative tests. But besides the traditional classification of mental powers, there is another of perhaps greater importance in studying differences between men. One individual differs from another not so much in power of memory, or of reasoning, or of attention, or of will, as in the sort of material to which he successfully applies these processes. One gives his attention readily to mathematics; he remembers mathematics easily; he reasons well on mathematical subjects; his will is strong in excluding distracting impulses when he is in pursuit of a mathematical goal. He may show none of these powers, in a high degree, in relation to music, or business, or social life; whereas another, totally inefficient in mathematics, may show equal powers of mind in another subject. The capacity to handle a given sort of subject matter is in part determined by native endowment, but is very responsive to training, and therefore is hard to test, because only individuals with equal training in any subject can be fairly tested and compared as to their native capacity to handle that subject. Thus it becomes hard to contrive a test for musical or mathematical or mechanical endowment which could fairly be applied to races having diverse trainings in these lines. This difficulty, moreover, infects our tests for such general powers as memory or reasoning, for a test has to deal with some sort of material, and success in passing the test depends on the familiarity of the material as well as on the power of mind which we design to test. We may suppose, indeed, that all of our tests, founded as they are on material which is familiar to us, will be more or less unfair to peoples of very different cultures and modes of life. The results of our tests need to be discounted somewhat—exactly how much we can not say—in favor of the primitive peoples tested.

We are now, it would seem, sufficiently entrenched in precautions and criticisms to admit the psychologist to our councils, and hear the results of his tests.

First, as to the senses. The point of special interest here is as to whether the statements of many travelers, ascribing to the "savage" extraordinary powers of vision, hearing and smell, can be substantiated by exact tests. The common opinion, based on such reports, is, or has been, that savages are gifted with sensory powers quite beyond anything of which the European is capable; though Spencer explains

that this is a cause of inferiority rather than the reverse, because the savage is thus led to rely wholly on his keen senses, and to devote his whole attention to sense impressions, to the neglect and atrophy of his intellectual powers. Ranke, however, on testing natives of Brazil, a race notable for its feats of vision, found that their ability to discern the position of a letter or similar character at a distance, though good, was not remarkable, but fell within the range of European powers. The steppe-dwelling Kalmuks, also renowned for distant vision, being able to detect the dust of a herd of cattle at a greater distance with the naked eye than a European could with a telescope, have also been examined; and their acuity was indeed found to be very high, averaging considerably above that of Europeans; yet only one or two out of the forty individuals tested exceeded the European record, while the great majority fell within the range of good European eyes. Much the same result has been obtained from Arabs, Egyptians and quite a variety of peoples. Among the most reliable results are those of Rivers on a wholly unselected Papuan population. He found no very exceptional individual among 115 tested, yet the average was somewhat better than that of Europeans. I had myself, through the kindness of Dr. McGee, the opportunity of testing individuals from quite a variety of races at the St. Louis Fair in 1904, and my results agree closely with those already cited, though I did not find any cases of very exceptional powers among about 300 individuals. There were a number who exceeded the best of the 200 whites whom I also tested under the same conditions, but none who exceeded or equaled the record of a few individuals who have been found in the German army. Indians and Filipinos ranked highest, averaging about 10 per cent. better than whites, when all individuals of really defective vision were excluded. The amount of overlapping is indicated by stating that 65–75 per cent. of Indians and Filipinos exceeded the average for whites. It did not seem possible, however, to assert anything like a correspondence between eyesight and the degree of primitiveness or backwardness of a people; since, for instance, the Negritos of the Philippine Islands, though much more primitive than the Malayan Filipinos in their mode of life, and, indeed, the most primitive group so far tested, were inferior to the Filipinos, and, in fact, as far as could be judged from the small number examined, no whit superior to whites. Nor does it seem possible, from results hitherto reported, to believe in a close correspondence between keen sight and dark skin, though it is true that pigment is important in several ways to the eye, and that therefore, as Rivers has suggested, the amount of pigmentation might be a factor in vision. But it does not seem to be specially the darkest races that show the keenest vision. We may perhaps conclude that eyesight is a function which varies somewhat in efficiency with difference of race, though with much overlapping. No doubt, however, the results as they stand need some qualification. On the one hand, inclusion of individuals with myopia and similar defects would lower the average of Europeans considerably more than that of most other races; so that the actual condition of eyesight differs more than the results show. On the other hand, it would not be fair to include near-sighted individuals, if what we wish to discover is native differences between peoples; for the different prevalence of myopia is certainly due to the differing uses to which the eye is put. And this matter of use may have considerable influence on the individuals not classed as near-sighted, and so admitted to the comparison.

Rivers has made an observation in connection with the test for eyesight, which I am able to confirm, and which is perhaps of much importance. He found that when the letter or character used in his test, the position of which had to be recognized at the greatest possible distance, was removed from him beyond the distance at which he felt that he could judge it, he could still guess it right nearly every time, though without confidence. By such guessing, one's record in this test can be bettered considerably; and careful study enables one to see the slight and blurred indications of position which form the basis of the guessing. Now it may well be that the occupations of civilized life breed a habit of dependence on clear vision, whereas the life of those who must frequently recognize objects at a great distance breeds reliance on slight indications, and so creates a favorable attitude for the test of eyesight. When this possibility is taken in connection with the deterioration of many European eyes from abuse, and in connection with the observed overlapping of all groups tested, the conclusion is not improbable that, after all, the races are essentially equal in keenness of vision. Even if small differences do exist, it is fairly certain that the wonderful feats of distant vision ascribed to savages are due to practise in interpreting slight indications of familiar objects. Both Rivers and Ranke, on testing some of the very individuals whose feats of keen sight seemed almost miraculous, found that, as tested, they had excellent but not extraordinary vision. A little acquaintance with sailors on shipboard is enough to dispel the illusion that such feats are beyond the powers of the white man.

The hearing of savages enjoys a reputation, among travelers, similar to that of their sight; but there can be little doubt that the cause is the same. In fact, the tests which have so far been made tend to show that the hearing of whites is superior. Such was the result of Myers on the Papuans, and of Bruner in his extensive series of measurements made at the St. Louis Fair. Only 15 per cent. of 137 Filipinos tested did as well as the average of whites; other groups made a somewhat better showing, but all seemed inferior on the average to whites. In spite of the experimental results, there is perhaps reason to doubt that the hearing of whites is essentially and natively much superior to that of other races. Civilized life protects the ear from some forms of injury to which it is exposed in more primitive conditions; and, then, the question of cleanliness must be considered in regard to the meatus. Besides, the ear is known to be highly susceptible of training in the perception of particular sorts of sound—as overtones and difference tones—and it is likely enough that the watch ticks and similar clicks used in the tests are not equally within the repertory of all peoples.

Much the same can be said regarding keenness of smell. On account of the high olfactory powers of dogs and some other lower animals, it has often seemed natural and proper that this sense should be highly developed among savages; and feats of primitive folk have been reported quite analogous to those already referred to under sight and hearing. No doubt here again, special interests and training are responsible, since what few tests have been made tend to show no higher acuity of smell among negroes and Papuans than among Europeans.

The sense of touch has been little examined. McDougall found among the Papuans a number with extremely fine powers of discrimination by the skin. The difference between two points and one could be told by these individuals even when the

two points were brought very close together; on the average, the Papuans tested excelled Europeans considerably in this test. On the other hand, Indians and Filipinos, and a few Africans and Ainu, tested in the same manner, seem not to differ perceptibly from whites.

The pain sense is a matter of some interest, because of the fortitude or stolidity displayed by some races towards physical suffering. It may be, and has been conjectured, that the sense for pain is blunt in these races, as it is known to be in some individuals who have allowed themselves to be burned without flinching, and performed other feats of fortitude. The pain sense is tested by applying gradually increasing pressure to some portion of the skin, and requiring the person tested to indicate when he first begins to feel pain. Now, as a matter of fact, the results of McDougall on the Papuans, and those of Dr. Bruner and myself on Indians, Filipinos, Africans and Ainu, are in close agreement on this point. Greater pressure on the skin is needed to produce pain in each of these races than in whites. This is the average result, but in this test the distribution of the cases is specially important. Though most whites feel pain at or about a certain small pressure, there is quite a respectable minority who give no sign till much higher pressures are reached, their results corresponding very closely to those of the majority of Indians. And similarly, a minority of Indians feel pain at much lower pressures than the bulk of their fellows, falling into the ranks of the white man. In each group, the distribution is bimodal, or aggregated about two points instead of one; but whites are principally aggregated about the lower center, and Indians and other races about the higher center. Introspection comes to our aid in explaining this anomaly, for it shows that there is some difficulty in telling just when the pressure becomes painful. If one is satisfied with slight discomfort, a moderate pressure will be enough; but if a sharp twinge is demanded, the pressure must be considerably increased. Most whites, under the conditions of the test, are satisfied with slight discomfort, while my impression in watching the Indians was that they were waiting to be really hurt. The racial difference would accordingly be one in the conception of pain, or in understanding the test, rather than in the pain sense.

On the whole, the keenness of the senses seems to be about on a par in the various races of mankind. Differences exist among the members of any race, and it is not improbable that differences exist between the averages of certain groups, especially when these are small, isolated and much inbred. Rivers has in fact found such small groups differing considerably from whites in the color sense. One such group showed no cases of our common color blindness or red-green blindness, while another group showed an unusually large percentage of color-blind individuals. In the larger groups, the percentage of the color-blind is, very likely, about constant, though the existing records tend to show a somewhat lower proportion among Mongolians than among whites. Very large numbers of individuals need, however, to be tested in order to determine such a proportion closely; even among Europeans, the proportion can not yet be regarded as finally established. One thing is definitely shown by the tests that have been made for color blindness in various races: no race, however primitive, has been discovered in which red-green blindness was the universal or general condition; and this is a fact of some interest in connection with the physiology of color vision, for it seems probable that red-green blindness, since it

is not by any means a diseased condition, represents a reversion to a more primitive state of the color sense. If this is so, no race of men remains in the primitive stages of the evolution of the color sense; the development of a color sense substantially to the condition in which we have it, was probably a pre-human achievement.

In the actual history of the discussion of the color sense in various races, quite a different view of the evolution has been prominent. It was Gladstone who first, as an enthusiastic student of Homer, was struck by the poverty of color names in ancient literature, and who suggested that the Greeks of the Homeric age had a very imperfectly developed eye for color. He was especially impressed by the application of the same color name to blue and to gray and dark objects. Geiger, adhering to the same sort of philological evidence, broadened its scope by pointing out the absence of a name for blue in other ancient literatures. It is indeed curious that the sky, which is mentioned hundreds of times in the Vedas and the Old Testament, is never referred to as blue. The oldest literatures show a similar absence of names for green. Geiger found that names for black, white and red were the oldest, and that names for yellow, green and blue have appeared in that order. He concluded that the history of language afforded an insight into the evolution of the color sense, and that, accordingly, the first color to be sensed was red, the others following in the same order in which they occur in the spectrum. Magnus found that many languages at the present day were in the same condition as that shown in the ancient Greek, Hebrew and Sanscrit. Very many, perhaps the majority, have no specific name for blue, and a large proportion have none also for green. A smaller number are without a name for yellow, while nearly all have a name for red. It seemed that the backward races of to-day had just reached the stage, in the matter of color sensation, which was attained by other races some thousands of years ago. The underlying assumptions of this argument are interesting—the notion that the list of sensations experienced by a people must find expression in its vocabulary; and the conception of certain peoples now living as really primitive. Fortunately, Magnus submitted this theory to the test of facts, by supplying travelers and traders with sets of colors, by which various peoples were tested, first, as to their ability to name the colors in their own languages, and second, as to their power to recognize and distinguish the colors. The results of this inquiry were that names were often lacking for blue and green, but that every people was able to perceive the whole gamut of colors known to the European. This was a severe blow alike to the philological line of argument and to the ready assumption that early stages of evolution were to be found represented in the backward peoples of to-day. Accepting the facts as they stood, Magnus still felt that there must be some physiological or sensory reason for the curious lack of certain color names in many languages; and he therefore suggested that blue and green might be less vividly presented by the senses of many tribes, and that, being duller to their eyes than to Europeans, these colors did not win their way into the language. The theory was, however, practically defunct for many years till Rivers recently took it up, as the result of tests on several dark-skinned peoples. His test called for the detection of very faint tints of the various colors, and the result was that, as compared with twoscore educated English whom he also tested, these peoples were somewhat deficient in the detection of faint tints of blue—and also of yellow—but

not of red. One group, indeed, was superior to the English in red. The results made it seem probable to Rivers that blue was indeed a somewhat less vivid color to dark-skinned races than to Europeans, and he suggested that pigmentation, rather than primitiveness, might be the important factor in producing this difference. A blue-absorbing pigment is always present in the retina, and the amount of it might very well be greater in generally pigmented races. The suggestion is worth putting to a further test; but, meanwhile, the difference obtained by Rivers in sensitiveness to blue needs to be received with some caution, since the Europeans on whose color sense he relies for comparison were rather few in number, educated and remarkably variable among themselves. We were able, at St. Louis, to try on representatives of a number of races a difficult color matching test, so different indeed from that of Rivers that our results can not be used as a direct check on his; with the result that all other races were inferior to whites in their general success in color matching, but that no special deficiency appeared in the blues. We also could find no correlation between ill success in this test and the degree of pigmentation. On the whole, the color sense is probably very much the same all over the world.

That linguistic evidence is a very treacherous guide to the sensory powers of a people is well seen in the case of smell. Certainly many odors are vivid enough, yet we have no specific odor names. Only a psychologist would require a complete vocabulary of sensations; practical needs lead the development of language in quite other directions.

When we turn from the senses to other functions, the information which the psychologist has to offer becomes even more scanty.

Some interest attaches to tests of the speed of simple mental and motor performances, since, though the mental process is very simple, some indication may be afforded of the speed of brain action. The reaction time test has been measured on representatives of a few races, with the general result that the time consumed is about the same in widely different groups. The familiar "tapping test," which measures the rate at which the brain can at will discharge a series of impulses to the same muscle, was tried at St. Louis on a wide variety of folk, without disclosing marked differences between groups. The differences were somewhat greater when the movement, besides being rapid, had to be accurate in aim. The Eskimos excelled all others in this latter test, while the poorest record was made by the Patagonians and the Cocopa Indians—which groups were, however, represented by only a few individuals. The Filipinos, who were very fully represented, seemed undeniably superior to whites in this test, though, of course, with plenty of overlapping.

The degree of right-handedness has been asserted to vary in different races, and the favoring of one hand has been interpreted as conducive to specialization and so to civilization. We were, however, unable to detect any marked difference in the degree of right-handedness in different races, as tested by the comparative strength, quickness or accuracy of the two hands. The Negritos, the lowest race examined, had the same degree of right-handedness as Filipinos, or Indians, or whites.

We are probably justified in inferring from the results cited that the sensory and motor processes, and the elementary brain activities, though differing in degree from one individual to another, are about the same from one race to another.

Equitable tests of the distinctly intel-

lectual processes are hard to devise, since much depends on the familiarity of the material used. Few tests of this nature have as yet been attempted on different races.

There are a number of illusions and constant errors of judgment which are well-known in the psychological laboratory, and which seem to depend, not on peculiarities of the sense organs, but on quirks and twists in the process of judgment. A few of these have been made the matter of comparative tests, with the result that peoples of widely different cultures are subject to the same errors, and in about the same degree. There is an illusion which occurs when an object, which looks heavier than it is, is lifted by the hand; it then feels, not only lighter than it looks, but even lighter than it really is. The contrast between the look and the feel of the thing plays havoc with the judgment. Women are, on the average, more subject to this illusion than men. The amount of this illusion has been measured in several peoples, and found to be, with one or two exceptions, about the same in all. Certain visual illusions, in which the apparent length or direction of a line is greatly altered by the neighborhood of other lines, have similarly been found present in all races tested, and to about the same degree. As far as they go, these results tend to show that simple sorts of judgment, being subject to the same disturbances, proceed in the same manner among various peoples; so that the similarity of the races in mental processes extends at least one step beyond sensation.

The mere fact that members of the inferior races are suitable subjects for psychological tests and experiments is of some value in appraising their mentality. Rivers and his collaborators approached the natives of Torres Straits with some misgivings, fearing that they would not possess the necessary powers of sustained concentration. Elaborate introspections, indeed, they did not secure from these people, but, in any experiment that called for straightforward observation, they found them admirable subjects for the psychologist. Locating the blind spot, and other observations with indirect vision, which are usually accounted a strain on the attention, were successfully performed. If tests are put in such form as to appeal to the interests of the primitive man, he can be relied on for sustained attention. Statements sometimes met with to the effect that such and such a tribe is deficient in powers of attention, because, when the visitor began to quiz them on matters of linguistics, etc., they complained of headache and ran away, sound a bit naïve. Much the same observations could be reported by college professors, regarding the natives gathered in their class rooms.

A good test for intelligence would be much appreciated by the comparative psychologist, since, in spite of equal standing in such rudimentary matters as the senses and bodily movement, attention and the simpler sorts of judgment, it might still be that great differences in mental efficiency existed between different groups of men. Probably no single test could do justice to so complex a trait as intelligence. Two important features of intelligent action are quickness in seizing the key to a novel situation, and firmness in limiting activity to the right direction, and suppressing acts which are obviously useless for the purpose in hand. A simple test which calls for these qualities is the so-called "form test." There are a number of blocks of different shapes, and a board with holes to match the blocks. The blocks and board are placed before a person, and he is told to put the blocks in the holes in the shortest possible time. The key to the situation is here the

matching of blocks and holes by their shape; and the part of intelligence is to hold firmly to this obvious necessity, wasting no time in trying to force a round block into a square hole. The demand on intelligence certainly seems slight enough; and the test would probably not differentiate between a Newton and you or me; but it does suffice to catch the feeble-minded, the young child, or the chimpanzee, as any of these is likely to fail altogether, or at least to waste much time in random moves and vain efforts. This test was tried on representatives of several races, and considerable differences appeared. As between whites, Indians, Eskimos, Ainus, Filipinos and Singhalese, the average differences were small, and much overlapping occurred. As between these groups, however, and the Igorot and Negrito from the Philippines and a few reputed Pygmies from the Congo, the average differences were great, and the overlapping was small. Another rather similar test for intelligence, which was tried on some of these groups, gave them the same relative rank. The results of the test agreed closely with the general impression left on the minds of the experimenters by considerable association with the people tested. And, finally, the relative size of the cranium, as indicated, roughly, by the product of its three external dimensions, agreed closely in these groups with their appearance of intelligence, and with their standing in the form test. If the results could be taken at their face value, they would indicate differences of intelligence between races, giving such groups as the Pygmy and Negrito a low station as compared with most of mankind. The fairness of the test is not, however, beyond question; it may have been of a more unfamiliar sort to these wild hunting folk than to more settled groups. This crumb is, at any rate, about all the testing psychologist has yet to offer on the question of racial differences in intelligence.

In the absence of first-hand study of the mental powers of different races, folk psychology resorts to a comparison of their civilizations and achievements. This is the method by which we habitually compare the intelligence of individuals, judging capacity by performance, the tree by its fruits; and such judgments, though subject to occasional error, are probably in the main reliable. Why should we not extend the method to the comparison of groups, and say that a group possessing a high civilization has probably a high average intelligence, while a wild savage race is mentally poorly endowed? The first difficulty in employing the method is to obtain a just estimate of the cultures to be compared. First impressions regarding alien folk, derived from the reports of travelers, are usually wide of the mark. Only the patient and prolonged labors of the ethnologist can inform us as to what a tribe does and thinks; and where such studies have been made, it is found that a backward culture, such as that of the natives of Australia, has much more substance, and affords much wider scope for mental activity, than the early reports indicated.

The difficulty of inferring the mental endowment of a group from its stage of culture is well brought out by applying this method to the comparison of different epochs in the history of a nation. German culture to-day is much advanced from the days of Cæsar; shall we infer that the mental endowment of the Germans has advanced in like measure? Biologically, the interval, measured in generations, is not long, and from all biological considerations it is improbable that any advance in mental endowment has occurred. The difference in material civilization does not mean that

the German of to-day is, on the average, gifted with more native inventiveness or business ability than his ancestors sixty generations ago. The difference in the arts and sciences does not mean that the German of to-day is naturally more studious, or scientific, or musical. The more settled condition of society does not imply greater native capacity for industry or government. The disappearance of old superstitions does not imply that later generations were born without the tendencies to superstition which characterized their fathers. We are still not many generations removed from witchcraft, curses, magic and the like savage beliefs and practises, and we can not reasonably believe our recent forefathers to have been naturally more savage than we are. When, for psychological purposes, we compare the culture of Europe with that of Africa, we should not leave out of account the Children's Crusade, or the Inquisition, or the Wars of the Roses. And if we attempt to use the state of civilization as a measure of racial intelligence, we must somehow adapt the method so that it shall give the same results, whether earlier or later stages in the culture of a group be taken as the basis for study.

In reality, the civilization possessed by a generation can not be used as a measure of the intelligence of that generation any more than an individual's property can be taken as a measure of his business ability. The greatest part of the civilization of a generation is bequeathed to it, and only the increase which it produces can be laid to its credit. If we could compare the rate of progress in different groups, this might serve as a measure of intelligence; and certainly some peoples are more progressive than others. Before adopting such a test, we should understand the mechanism of progress—a matter which belongs only in part to psychology.

Progress depends first of all on human inventiveness—so much will probably be allowed. Under the head of inventions should be included, not only mechanical devices, but works of art and government, business enterprises and changes in custom, so far as any of these demand originality in their producers. Science and all increase in knowledge should also be included, since the process of discovery differs but little from the process of invention. In both the essential mental act seems to be a bringing together of things that are found apart, or a pulling apart of what occurs together. In fact, both of these processes, the combining or associating, and the analytic or discriminating, go on together, since we see something new in a thing when we are reminded by it of something else and different. There is a suggestion of the accidental in all invention, since it depends on "happening to notice something," or "happening to be reminded of something." You can not be sure that a person will make a discovery, even when you supply him with the elements which would combine to produce it. Oftentimes, in reading the history of scientific progress, one is surprised that a certain discovery was not made by some man who had apparently everything before him to lead to it. Invention is of the nature of a spontaneous variation, and this accidental character is very important in understanding the mechanism of progress.

On the other hand, since one can not be reminded of things entirely unknown, invention depends on previously acquired knowledge, and the inventiveness of an individual must take a direction prepared for him by the social group among which he lives. A large share of the inventiveness of the Australian natives seems to be

directed into the channels of magic and ceremony. The finished product of one mind's inventiveness becomes raw material for another, and invention of all sorts is distinctly a cooperative enterprise.

Invention is said to be mothered by necessity; and the proverb is no doubt true in the main, though curiosity and experimentation belong among the play instincts. But, in any case, the necessity must not be too dire, for some degree of leisure is demanded if anything novel is to be thought of, and rapid progress is only possible when individuals can be allowed to accumulate the special knowledge which may serve as the raw material for their inventive activity. Divisions of labor, guilds, universities, legislatures, investigating commissions, permanent research bureaus—each of which is, genetically, a series of inventions—are dependent for their existence on a certain degree of leisure, while they in turn provide more leisure and opportunity for further advance. They are inventions which accelerate the progress of invention. There are thus many factors besides the intellectual endowment of a generation which go to determine the progress which it shall make. The spur of necessity, the opportunity afforded by leisure, the existing stock of knowledge and inventions and the factor of apparent accident or luck have all to be considered.

A still further factor is the size of the group, which is deserving of renewed attention. Not only does a large group afford more opportunity for division of labor and special institutions for research, but the biological consideration already mentioned should be emphasized. The contributions to progress of the average man are small, the inventions of moment arising in the brains of a small fraction of the group. A large group provides a greater number of inventive minds, and it is rather the absolute number of such than their proportion to the whole population that determines the progress of invention within a group. The "group" needs to be redefined from the point of view of invention. If knowledge and inventions pass back and forth between two nations or races, the inventive minds of both are brought into cooperation, and the group is by so much enlarged. From the point of view of progress, however, the question is not simply how many inventive minds are brought into coöperation, but how free and rapid the communication is between them. At the present time, a discovery originating anywhere in Europe or its colonies is quickly known by specialists in all parts, and may promptly fructify the mind of a distant investigator, leading to a fresh advance. The invention of printing and of rapid means of communication must be credited with a large share of the rapid progress which has been made by the last few generations. Much also must be credited to the invention of steam power, which has vastly multiplied the size of the European group, in an economic sense, and set free many minds of ability for productive thinking. The very idea of the advancement of science and invention as an end to be striven for is to be classed as an invention, and a rather recent one; and it too is an accelerator.

Such considerations provide at least a partial explanation of the different rates of progress in different generations, and among different races. Whether they explain everything could perhaps only be determined by a drastic experiment, which it will do no harm to imagine, though the question will never be settled in this convincing way.

Let two or more habitats, isolated from each other and from the rest of the world, and as nearly as possible alike, be chosen,

and peopled by two equal groups of children, selected from some highly civilized nation, and so selected as to represent fairly the distribution of mental and physical traits among that nation. For every individual in the first group, let there be a practically identical individual in the second. Let these groups of children be introduced into their new homes in infancy, and, by some quasi-miraculous means, let them be all preserved to maturity, and then let them, and their descendants, be left entirely to their own devices, without fire, or a language, or other modern improvements. To watch such a spectacle from afar would be thrilling, if not too pitiful. We can readily grant that the infant communities would begin at the very zero of civilization, and that their progress, for many generations, would seem excessively slow. But the real point of the experiment is to inquire whether these two equal groups, alike in numbers, in heredity and in environment, would remain alike, and progress at equal rates. Probably they would not. We must allow for a large element of chance in the mating of males and females within each group, and consequently for changes and inequalities in the distribution and correlation of traits—changes which need not alter the average of either group. We must allow for spontaneous variation in the offspring, another accidental factor by virtue of which a really inventive and effective individual, or conjunction of such, would almost certainly arise in one group earlier than in the other, and give the advance of one group an impetus which might be felt through many generations, and carry this group far ahead of the other. And we must allow also for the accidental factor in invention. Even though the genius of one group was paired by an equal genius in the other, it is improbable that both would invent the same things. One might invent a hunting implement, and the other a fishing implement; and by this accident the direction of development might be settled for each group. If we closed the experiment after a thousand generations, we should probably find two peoples of different languages, different customs, and cultures divergent in many respects. The supposed result may be taken as an assertion of the importance of accident in determining the destiny of peoples. Obscure causes are no doubt at work beneath the accidents, but we can not trace them, nor reasonably state them in terms of racial superiority and inferiority.

It would seem that size of groups, and accidental factors, exert so much influence on the rate of advance in civilization that differences of culture could possibly be explained without supposing the mental endowments of the races to differ. Whether the existing races of men do or do not differ in such a trait as inventiveness is another and more difficult problem, the settlement of which must be left to time and educational experiments. The experiments must be continued for several generations, in order to equate social traditions. Regarding the negroes of the south, I am informed by a gentleman who has spent twenty years in educating them that a distinct advance is perceptible during this period, especially among the children of educated parents. These have more educational ambition, enter school earlier and have less to unlearn. The educational experiment, as far as it has gone, thus shows that much time will be needed before a clear result is reached.

Meanwhile it may be allowed to add one more general consideration by asking whether causes of a biological nature can be seen to be at work in human history, such as would differentiate the races intellectually, and, in particular, such as to

raise up, in some part of the world, a race superior to the stock from which it sprang.

Natural selection has been suggested as such a cause. Life in the tropics, it has been said, is too easy to demand much inventiveness or forethought, but a migration to colder regions, where the banana does not grow, would make mental activity imperative, and select those individuals who were able to respond, so producing a superior race. There is a difficulty here, since we should expect natural selection to begin by lopping off the most poorly endowed fraction of the population, with the result, finally, that the lower range of intelligence should disappear from the higher races. The lowest grade of intelligence in Europe should accordingly be higher than the lowest grade in Africa. But this is probably not the case; the range of intelligence reaches as low in one as in the other. The distributions of intelligence in the two also overlap to quite an extent. Extensive experiment has shown that Africans can maintain existence in the temperate zone.

Sexual selection, or, more properly, mating customs, furnish a more promising factor. If a tendency could be detected in any population for the most intelligent members to mate with each other, the result would be, not indeed a raising of the average intelligence, since the less intelligent would also mate with each other, but an increase of the variability, and greater chance of the birth of very superior individuals. A caste system might operate in this way, since the founders of aristocratic families probably won admission to the caste partly by virtue of intelligence, and their descendants would tend, by heredity, to exceed the average intelligence of the population. Marriage confined to the caste would thus tend to mate superior individuals with each other, and might, in the course of generations, raise the upper limit of intelligence. Customs of mating within one's rank obtain among the aristocracy and royalty of Europe, and may have been a factor in increasing the number of superior intelligences. But too much can not be attributed to this factor, since the selection has been by classes, and not by individuals. Royalty, while marrying within its rank, has not usually chosen the most gifted individual available. Its selection has been relatively inefficient from the standpoint of royal eugenics. Certainly the upper reach of European intelligence has not been the result of breeding by castes; for, though royalty has indeed produced a disproportionate number of high intelligences, equally able individuals have, as a matter of fact, risen from humble birth. Moreover, marriage in all parts of the world is largely governed by considerations of family standing and wealth, so that the same sort of influence toward variability is everywhere operative. The dead level of intelligence, which is sometimes supposed to obtain among backward races, is not borne out by psychological tests, since individual differences are abundantly found among all races, and, indeed, the variability of different groups seems, from these tests, to be about on a par.

Selection by migration is also to be considered. When individuals leave their group and go to a new country, it would seem that those who emigrate must differ, on the average, from those who remain behind. An adventurous and enterprising spirit, perhaps, would be characteristic of the emigrants, and so of the new people which they helped to form. On the other hand, the ne'er-do-well and the criminal might also be induced to emigrate. The selective influence of migration would not be all in one direction, and the net result could not easily be predicted. Since we are now witnessing, though little compre-

hending, this process of migration as it contributes to form a people of the future, information regarding the kind of selective influence exerted by migration would have a practical value. Wisdom would dictate that the nation which is in process of formation should exert some selective influence on its own account, but, from all the facts in hand, the part of wisdom would be to select the best individuals available from every source, rather than, trusting to the illusory appearance of great racial differences in mental and moral traits, to make the selection in terms of races or nations.

R. S. Woodworth

Columbia University

SCIENTIFIC NOTES AND NEWS

The Geological Society of London has awarded the Wollaston medal to Professor W. B. Scott, of Princeton University, "in recognition of his many valuable contributions to our knowledge concerning the mineral structure of the earth, and especially in relation to the tertiary mammalia and tertiary stratigraphical geology of North America and Patagonia."

At the recent meeting in Boston, Dr. George A. Piersol, professor of anatomy, was elected president of the American Association of Anatomists.

Drs. Charles H. Frazier, John H. Musser, David L. Edsall and A. C. Abbott have been appointed by Provost Harrison, of the University of Pennsylvania, managers of the Phipps Institute for the purpose of entering upon the construction of the new building with the money contributed by Mr. Phipps.

Mr. A. F. Woods left Washington on January 23 to take up his new duties at the University of Minnesota. On the evening of January 22 he was tendered a reception by the Bureau of Plant Industry, at which time a silver service was presented to him in commemoration of his long service in the bureau. Addresses were made by Assistant Secretary Hays, Mr. D. G. Fairchild and Dr. Erwin F. Smith.

A dinner in honor of Professor James Truman, emeritus professor in the University of Pennsylvania Dental School, was given at the Waldorf-Astoria, in New York City, on January 23.

On the occasion of the inaguration of Dr. H. H. Apple, as president of Franklin and Marshall College, on January 7, the degree of LL.D. was conferred on Dr. Edgar F. Smith, vice-provost of the University of Pennsylvania and professor of chemistry, and on Dr. J. H. Musser, professor of clinical medicine of the University of Pennsylvania.

Dr. Albert Ladenburg, professor of chemistry at Breslau, has been elected a corresponding member of the Paris Academy of Sciences.

Dr. Otto N. Witt, professor of industrial chemistry in the Berlin School of Technology, has been made an honorary member of the Royal Institution, London.

Mr. T. Case, Waynflete professor of moral and metaphysical philosophy and president of Corpus Christi College, Oxford University, has resigned his professorship.

Dr. C. O. Townsend, pathologist in charge of sugar beet investigations, Bureau of Plant Industry, has resigned from the government service. He left Washington on January 17, for Garden City, Kansas, where he has accepted a position as consulting agriculturist for a large sugar beet company.

Professor F. W. Morse, formerly chemist of the New Hampshire Experiment Station and professor of organic chemistry in the New Hampshire College, has been engaged temporarily as research chemist at the Massachusetts Agricultural Experiment Station.

The board of directors of the Metropolitan Life Insurance Company has appointed Dr. Jay Bergen Ogden, to be assistant medical director of the company.

Dr. Hans Hallier, conservator of the Royal Herbarium at Leyden, has been visiting the botanical gardens of the United States.

PROFESSOR N. E. GILBERT, of the department of physics of Dartmouth College, has gone to study at Cambridge University during his sabbatical year.

DR. CHAUNCEY JUDAY, lecturer in zoology at the University of Wisconsin, has gone to Central America, where he will spend a month studying lakes, particularly those formed in volcanic craters, in Guatemala.

AN archeological expedition from Princeton University will leave early in February. Professor Howard Crosby Butler, who has led three expeditions to Syria, will sail on February 8 for Constantinople, where he will perfect the arrangements for the new expedition, which will work in Asia Minor.

MR. ECKLEY B. COXE, JR., of Philadelphia, founder of the Eckley B. Coxe, Jr., expeditions into Nubia of the University of Pennsylvania, has been made president of the archeological department of that university.

DR. W. A. MURRILL, assistant director of the New York Botanical Garden, has sailed for southern Mexico, to continue his studies of tropical fungi. He is accompanied by Mrs. Murrill.

AT a meeting of the American Philosophical Society, to be held on February 4, Professor Francis G. Benedict, of the Carnegie Nutrition Laboratory, Boston, will read a paper on "The Influence of Mental and Muscular Work on Nutritive Processes."

PROFESSOR JAMES F. KEMP, of Columbia University, gave a lecture before the geological department of Colgate University on the evening of January 28. His subject was "The Physiography of the Adirondacks."

AT the regular monthly meeting of the Oregon Academy of Sciences held on January 15 an address was delivered by Mr. Ira E. Purdin on "Local Geological Conditions." The annual meeting of the academy will be held on March 11 and 12.

MONDAY evening lectures before the College of Liberal Arts of Northwestern University have been given as follows:

December 20—"Our Present Knowledge of Human Lineage" (illustrated), by Professor William A. Locy, Ph.D., Sc.D.

January 10—"Some Alaskan Glaciers" (illustrated), by Professor Ulysses S. Grant, Ph.D.

January 24—"From Galileo to Kelvin, the Rise of Modern Physics," by Professor Henry Crew, Ph.D.

January 31—"Problems of Modern Astronomy" (illustrated), by Professor Philip Fox, M.S., director of Dearborn Observatory.

PROFESSOR HUGO MÜNSTERBERG, of Harvard University, delivered, on January 21, 1910, the second of the series of lectures being given during the college year by the Omega chapter of the Sigma Xi Society, at the Ohio State University, Columbus, O. He spoke on "The Psychologist in the Courtroom."

THE fortieth anniversary of the founding of the American Museum of Natural History will be celebrated on the afternoon of February 9, at which time a statue of Morris Ketchum Jesup will be unveiled. The commemoration and presentation address will be made by Mr. Joseph H. Choate.

THE Pennsylvania State Breeders' Association and Dairymen's Association held memorial services for Professor Leonard Pearson, at the University of Pennsylvania, on the evening of February 2. Dr. James Law delivered the principal address.

A PORTRAIT of Dr. Nathaniel Chapman, professor of medicine in the University of Pennsylvania from 1813 to 1850, was presented to the College of Physicians on January 5. The presentation was made by Dr. S. Weir Mitchell on behalf of Mrs. Henry Caldwalader Chapman in memory of her husband, the late Dr. Henry C. Chapman.

DR. JAMES F. CONNEFFE, assistant in the department of bacteriology, Ohio State University, Columbus, Ohio, died on Thursday, January 20, of typhus fever. Dr. Conneffe went to Mexico as a member of an expedition in charge of Associate Professor E. F. McCampbell, of Ohio State University, and contracted the disease while in Mexico. Dr. Conneffe was a graduate of the Medico-Chirurgical College of Philadelphia in 1906.

Probate has been granted of the will of Sir Alfred Jones, of whose benefactions to public objects some particulars have already been published. The estate is valued at £674,259. After some legacies to relatives and employees, Sir Alfred left the residue of his estate, which will probably exceed £500,000, for such public purposes and objects in England, or in any British possession on the west coast of Africa as his trustees may think fit. Five suggestions as to the purposes to which the money might be applied are made, the first three of which are: (*a*) The technical education of natives on the west coast of Africa; (*b*) the advancement, benefit or support of education or science; (*c*) original research of all kinds into the cause of diseases on the west coast of Africa.

The executive committee of the National Education Association announces that the forty-eighth annual convention will be held in Boston, Mass., July 2 to 8, 1910.

The third International Congress of School Hygiene will be held at Paris, August 2–7, 1910. The importance of the subject to which the congress pertains, and the interest manifested in the first congress held at Nuremburg in April, 1904, and in the second of the series held at London in August, 1907, justify the belief that the forthcoming congress will be largely attended, and that its deliberations will materially advance the efforts for the improved hygienic condition of schools and the physical well-being of school children. M. Duomergue, the minister of public instruction in France, has accepted the honorary presidency of the congress. The president is Dr. A. Mathieu, president of the French Association of School Hygiene, Paris, France. The medical inspector of schools, Paris, Dr. Dufestel, is the general secretary of the executive committee of the congress.

Funds have been raised by public subscription for the establishment of an astronomical observatory at Kamuki, Honolulu, to be used in the first instance for observations of Halley's comet. The observatory, however, will be permanent and under control of the College of Hawaii.

The Harvard Seismographic Station in the geological section of the university museum has been open to inspection by officers of the university and their families. Professor J. B. Woodworth or a representative has been present to explain the seismograph and to show the records obtained of distant earthquakes. During this week the station has been open to inspection by students in the university and their friends. The Students' Meteorological Observatory (on the roof of the Geological Museum), which is now partially equipped with instruments, has been open for inspection on the same days. Professor R. DeC. Ward or Mr. William G. Reed, Jr., has been present to explain the use of the instruments. The new model of the temperatures of Boston, recently placed in the museum exhibition rooms, were shown at the same time.

The council of the Royal College of Surgeons, in view of the fact that women medical students are to be admitted to the college diplomas in January, adopted a recommendation that the London and Edinburgh schools of medicine for women be added to the list of medical schools recognized by the two royal colleges.

From February 7 to 12 two seed and soil special trains will be run over the Vandalia line from St. Louis to Terre Haute and thence to Peoria. From Peoria the same party will travel on a train over the Toledo, Peoria and Western Railroad from Sheridan to Warsaw—from Indiana state line to the Mississippi. The speakers will be provided by the Agricultural Experiment Station of the University of Illinois and the trains by the railroad companies.

The Journal of the American Medical Association states that the Philadelphia County Medical Society had decided to establish a medical library for the use of its younger members. The library committee was authorized to contract with the Free Library of Philadelphia for the reservation of alcoves in the different branches throughout the city for medical books and publications. These works are to be selected by a committee composed of

Drs. James M. Anders, M. Howard Fussell, Herman Allen and Edward E. Montgomery. An initial appropriation of $300 was made by the society for the purchase of books and journals.

The desirability of establishing an international scale for the comparison of observations in solar radiation has led Mr. C. G. Abbot, director of the Smithsonian Astrophysical Observatory, to construct a standard "pyrheliometer." This instrument, tested by him both in Washington and at Mount Wilson in California, has been found to yield satisfactory results. Accordingly, a limited grant from the Hodgkins Fund of the Smithsonian Institution was made for the construction of four of these silver disk pyrheliometers. These have now been completed and are about to be sent to investigators in widely separated localities for use in obtaining constants. The first will be sent to M. Violle, who is chairman of the committee on solar radiation of the Solar Union, and by him will be placed in the meteorological station established by the French government on the Pic du Midi in the Pyrenees in the south of France. The second will go to M. Chistoni, of the Physical Institution in Naples, and will be sent to the observatory on Mount Vesuvius.

This government has received through the customary diplomatic channels, an announcement of the Official Exhibition of Art to be held at Buenos Aires, Argentine Republic, to commemorate the first centenary of the independence of the country. This exhibition will be opened on May 25, 1910, and will be continued until September 30, or later should the executive committee so decide. Full details with reference to the conditions of participation in the exhibit may be obtained by addressing El Senor Comisario General, Exposicion Internacional de Arte del Centenario, Cangallo 827, Buenos Aires, Republica Argentina.

UNIVERSITY AND EDUCATIONAL NEWS

Charitable and educational institutions received $162,000 by the will of Mrs. Frances E. Curtiss, of Chicago. Among the institutions benefited are Williams College, Williamstown, Mass., $25,000.

Cooper Medical College, San Francisco, has received a bequest of $5,000 by the will of the late Mrs. Myrick.

Plans are under way for the merger of the Jefferson, Medico-Chirurgical and Polyclinic Medical Colleges of Philadelphia and their connection with some university as its medical department.

The trustees of Syracuse University have recently voted in favor of the proposition to establish a College of Agriculture and Forestry in that institution. As a preliminary step there will be organized out of facilities already available an agricultural group and a forestry group of studies drawn especially from the departments of botany, chemistry, engineering, geology (including meteorology) and zoology. These courses will be open to election with the next collegiate year. Temporarily, the work of organization is to be under the direction of Professor William L. Bray, of the department of botany.

The total number in attendance last year for the two weeks' courses in agriculture and for the Corn Growers' and Stockmen's Conventions at the University of Illinois was 775. That number will be more than surpassed this year. More than 700 have already been registered, of whom 115 are women. The lectures are being given not only by men of the college, but by men of prominence from different parts of the state.

President Schurman, of Cornell University, said in a recent address: "I should like most to see at Cornell a score of research professorships with salaries, say $7,500 each, which would call for a capital of some $3,000,000 or $4,000,000, a really small amount in this age of American multi-millionaires."

Dr. Louis A. Klein, appointed last year professor of pharmacology and veterinary medicine, has now been made dean of the veterinary department of the University of Pennsylvania, to fill the vacancy occasioned by the death of Dr. Leonard Pearson.

Robert Bruce Brinsmade, B.S. (Washington University), E.M. (Lehigh), has accepted the chair of mining engineering at West Virginia University, replacing Henry Mau Payne, who has gone into other lines of work.

Mr. O. T. Jones, of the Geological Survey of England and Wales, has been appointed lecturer in geology and physical geography in University College, Aberystwyth.

Mr. H. J. Seymour, B.A., of the Geological Survey of Ireland, has been appointed professor of geology in University College, Dublin.

DISCUSSION AND CORRESPONDENCE

THE GREEN BUG AND ITS NATURAL ENEMIES

Professor Woodworth has very kindly sent me in advance a copy of his review of "The Green Bug and Its Natural Enemies." The views advanced by him are interesting and his interpretations somewhat out of the usual order.

1. He does not understand why data from the experimental laboratory studies were not used to show the potentiality of the parasite, *Lysiphlebus tritici,* over the green bug, *Toxoptera graminum.* No attempt was made to use the data in that way, since the contest between the two forms took place, not in the experimental laboratory, but under natural conditions in the open, over territory from central Texas northward through Oklahoma to central Kansas. Accordingly, it was stated (page 135), "The average number of green bugs killed by a single parasite under natural conditions is probably much larger than the above figures show," and reasons were there given for this opinion. Since that time corroborative evidence on this point has appeared as follows: "The female *Lysiphlebus* is even more prolific than the female *Toxoptera.* Mr. Phillips has found females which had upwards of four hundred eggs in their ovaries and Mr. Kelly has reared in some cases 206 individuals from a single mother *Lysiphlebus.*[1]

Obviously, then, figures or tables, such as prepared by the reviewer, based on data obtained under artificial conditions, would not form a safe basis for conclusions upon the outcome of such a struggle in the natural environments of the contestants.

However, since the reviewer has placed special stress upon the value of his tables it should be noted, as showing their bearing upon the laboratory experiments, that he takes the minimum period, five days, for development of the green bug and considers that as the average. That is, among 140 green bugs reared in laboratory under daily observation, four, or 2.8 per cent., gave birth to young on the fifth day, and this percentage he rates as the average. As a result he obtains 95,571 progeny for one green bug in thirty days, whereas the author, using the average summer rate, seven days, of development for 80 green bugs reared in laboratory under daily observation, obtains for the same period 15,794 (page 95)—a difference of 79,777 on the first basis of comparison. As to the parasite, the reviewer takes the average rate (page 7 based on results of several observers) of development of parasite in the open field, seven days, for his computation on the parasite.

That is, the behavior of 2.8 per cent. of the green bugs observed in the laboratory and the behavior of the average of all parasites observed in the open, are the factors which he uses to compute the potentiality of the parasite. Obviously, basal factors so unlike in quantity and conditions furnish no reliable foundation for comparisons from which to deduct safe conclusions. Furthermore, these factors are not representative of the data from which they are supposed to be taken.

Consequently, the subsequent computations and deductions upon his table as brought out by the reviewer, unique in themselves, would not seem to require further consideration here.

The statement of the author regarding the outcome of the struggle between the parasite and its host was not based upon deductions from the experimental laboratory data, but from the records of continuous field observations made during the entire time of the struggle by eight different reliable observers. The seven from the university were stationed from central Oklahoma to northern Kansas, as

[1] Circular No. 93 rev., p. 15, U. S. Dept. of Agric., B. of Ent., June 23, 1909.

shown by pages 13 to 30 of the bulletin. The eighth, Agent Sanborn, of the Federal Bureau, who had been working by assignment on this problem for a year previous, was present at the original outbreak in Texas and made personal observations back and forth from central Texas through Oklahoma to central Kansas.

The pertinent portions of these various field observations are to be found on the pages just cited, and all agree without qualifications that *Toxoptera graminum* had been vanquished by *L. tritici.* Moreover, every entomologist whose observations on this undue multiplication of *T. graminum* have since been published agree on this point.

From the information, then, at hand bearing upon the statement, "That this parasite not only controlled, but in many cases practically exterminated, the green bug last season no one questions," it would seem that, with the exception of the reviewer, this statement maintains.

2. The reviewer suggests the probability of the disappearance of the green bug being due to meteorological influences and cites from the report to show that climatic conditions inimical to the green bug do arise. Such conditions do arise, but, as Glenn has shown later in this report (pages 176 and 180), it is the extremes of summer and winter temperature that affect the green bug, while the struggle between these forms took place and was decided during April and May, within which time, as the records show, no such inimical climatic conditions existed.

3. On pages 150–155 of this bulletin it was shown in the laboratory experiments that *L. tritici* did parasitize certain aphids other than *T. graminum.* On page 156 the original description of *L. tritici* Ashmead is published, in which appears, "Reared June 20, 1882, from wheat Aphis, *Aphis avenæ.*" There does not, then, seem to be any evidence in this bulletin to support the reviewer's inference, that, "He [the author] considers the parasite to belong particularly with this species of Aphid."

4. In referring, however, to whether *Lysiphlebus* maintains a general distribution on these other hosts the reviewer calls attention to a pertinent question. The author believed and so stated many times during this outbreak prior to the middle of April, that this parasite existed quite generally over the country, supposedly on other aphid hosts. The author's opinion was modified during April by the cumulation of the following data:
(Pages 31 and 32.)

(*a*) The green bug was present in Kansas in December, 1906.

(*b*) During the first two weeks of April, eight widely separated localities throughout the wheat area of the state showed parasites present in but one place, and subsequent examination proved that to be a spot of very small area.

(*c*) During the same period of April an expert from the Federal Bureau of Entomology, sent here to study the situation, examined wheat fields in nine different parts of the state (Kansas) and found those places free from parasites, except at one point on the southern border, where, he states, "they are beginning to appear."

(*d*) Field experiments showed that parasites were absent until introduced.
(Pages 29 and 30.)

(*e*) Sanborn reported that *T. graminum* had continued to multiply during December and January over a comparatively large area of northern Texas under conditions favorable to the existence of the parasite and yet no parasite had appeared.

Then, later in the season, further evidence tended to confirm the opinion that *T. graminum* did not maintain a general distribution on other aphids: First, early in June, after weather favorable to both the artificial and natural distribution of the parasites, a conservative, trained observer found a large area in the northern part of the state (Kansas) where green bugs were present, but parasites, with one possible exception, only where introduced. Second, a serious outbreak of the green bug was reported from Washington, D. C., unattended by the parasite, and this at the close of July, a season most favorable for the activities of the parasite (page 32).

Since the meteorological conditions of the spring of 1907 were unusual, the author was

still of the opinion that in normal years the parasite would, in all probability, maintain a general distribution (page 26). During the spring and summer of 1909 a notable exception to this opinion existed in southwestern Oklahoma. Here the green bug was abundant over about one hundred square miles. This area was examined, first by a representative from the federal bureau about the middle of April and then by a member of the entomological department of the university of Kansas a month later, and neither of these entomologists found any evidence of the presence of the parasite. Reliable reports subsequently made to the author showed the green bugs present and the absence of the parasite during the entire growing season and this in a locality where parasites were superabundant two years previous and in a climate favorable to the existence and natural distribution of the parasite.

These are the evidences upon which the opinion was based that this parasite does not maintain a general distribution.

5. What the reviewer says regarding the Australian lady bird in California is important. The only reference to this insect in the bulletin is in connection with a historical summary of entomological endeavor in the control of one insect by the use of another. Since this lady bird is not referred to in the discussion of the green-bug problems, there does not appear to be anything to show that the behavior of this lady bird was used as corroborative evidence to strengthen any conclusions regarding the green bug and its parasite.

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GAMETOGENESIS OF THE SAWFLY NEMATUS RIBESII. A CORRECTION

In the *Quarterly Journal of Microscopical Science,* Vol. 51, 1907, p. 101, I described observations on the gametogenesis of *Nematus ribesii,* some of which subsequent work has shown to be erroneous. Since my statements have been quoted in several recent papers, I think it necessary to correct the mistakes as far as possible, although I have not yet reached a satisfactory solution of the phenomena. The errors arose partly through misinterpretation of the phenomena observed, and partly through imperfect fixation, for I find that, unless the material is very accurately fixed, the chromosomes tend to adhere together and give the appearance of a smaller number than the true one. The same cause has led other observers to make similar mistakes.

Reinvestigation of *Nematus* shows, in the first place, that there is only one division of the spermatocytes; the first division described in my paper is not a true mitosis, but is probably comparable with the abortive division observed in the spermatogenesis of the bee. I have not yet been able to determine the chromosome number with certainty. In the spermatogonia the number appears to be about sixteen, and that in spermatocyte mitoses about eight, but if eight is the true reduced number, the occurrence of sixteen in the spermatogonial mitoses of larvæ derived from parthenogenetic eggs is unexplained. In the bee, and as I find, also in a cynipid (to be published shortly), the spermatogonial number is the same as that of the spermatocytes.

I have not yet obtained fresh material for reinvestigation of the maturation of the egg, but the results of my recent work on the spermatogenesis make it clear that my observations on the chromosomes in the polar divisions also require revision.

But the behavior of the chromosomes in *Nematus ribesii* is so difficult to follow that it is possible that the true interpretation will be obtained only by the discovery of some nearly related species in which they are more clearly distinguishable.

Leonard Doncaster
University of Birmingham, England,
November, 1909

MOUNTAIN AND VALLEY WINDS IN THE CANADIAN SELKIRKS

To the Editor of Science: Report has been brought from British Columbia by Mr. C. T. Brodrick, of Harvard University, of an interesting case of the daytime descent of air

currents in mountain valleys. The fact of the nocturnal descent of air on mountain sides and along the floors of mountain valleys is familiar, and in some cases a deepening of the current during the night has been noted. The present report describes the method of occurrence of the lateral drainage only. The observer found that during the daytime, provided the sun shone, a distinct set of the air toward the valley bottoms was noticeable in the shadows of cliffs, while in the sunlight no movement was discernible. One case, where a vertical cliff cast a well-defined shadow, showed that by going even so short a distance as twenty-five feet, one moved from uncomfortable heat into a cooling breeze. This descent of air in the shadows was undoubtedly due to a cooling similar to the more often observed nocturnal phenomenon, though on a very small scale.

A similar control over *nocturnal* winds was noted by the writer a few years ago near the foot of the Illecillewaet Glacier, in the Canadian Selkirks. The valley of the Illecillwaet River, which flows northwestward from the glacier, is very steep walled. This, with the presence of the ice, affords ideal conditions for nocturnal downcast winds. About sunset on the day in question, the writer was standing near the foot of the glacier, but somewhat upon the east side of the valley. The air was perfectly calm, and the temperature in the full sunlight gave no indication of the presence of the ice. The west side of the valley was already in shadow. As the edge of this shadow crossed the valley floor, a distinct movement of foliage within the shadow became evident. The zone of movement widened, keeping pace with the advance of the shadow; and as the edge of the latter passed the observer on its way up the east wall of the valley, the edge of the zone of foliage movement lagged a hardly perceptible distance behind, and was seen to move up the slope to the limit of the bushes. Possible movement beyond this point was rendered invisible by the distance and character of vegetation on the higher slopes. Almost at the instant of the passing of the shadow edge, a gentle puff of cold wind down off the glacier announced the beginning of the nocturnal descent of air. Half an hour later, at the hotel some distance down the valley, the night wind was already blowing moderately and the temperature had dropped many degrees.

It is improbable that the upper limit of foliage movement indicated the depth of the down-valley current in "mid-stream." The rapidity of ascent of the shadow would call for the sudden beginning of movement of a mass of air so large that it could not possibly have been cooled thus quickly throughout. Instead, the upper limit of a relatively thin sheet of cooling air which was moving more or less directly toward the valley bottom, was indicated.

Observation may prove that this lateral movement, while showing near its upper limits a fairly direct downward course, turns more and more obliquely down the valley under the influence of the drag of the airstream proper. Careful study might also show whether the surfaces of such down-valley currents assume the slight convexity noted in the case of water-streams, or whether the constant lateral accessions of air tend to produce a diminishing concavity of surface as the stream slowly deepens during the night.

B. M. Varney

Harvard University,
January 6, 1910

SCIENTIFIC BOOKS

Outlines of Chemistry: A Text-Book for College Students. By Louis Kahlenberg, Ph.D., Professor of Chemistry and Director of the Course in Chemistry in the University of Wisconsin. New York, The Macmillan Co. 1909. Pp. vii + 548. $2.60 net.

In a clear and interesting style the author here presents such a course in elementary chemistry as was almost universally taught a generation ago and still keeps its place in many of our largest institutions of learning. Professor Kahlenberg has accomplished his purpose with a high degree of success, but we may nevertheless inquire with all seriousness whether this purpose is consistent with the

most efficient training of chemists as technicians and as thinkers.

Chemistry, it must be admitted, is still far from being an exact science, but an enormous stride has been made in this direction during the last few decades as a result of the work of such men as Guldberg and Waage, Gibbs, van't Hoff and Arrhenius. The exact laws and theories developed during this period constitute powerful weapons of research which are the birthright of the new generation of chemists. To withhold all knowledge of these illuminating ideas even in the most elementary course in chemistry is unjust to the student and to the science.

If the author had omitted all theory from his book and made it frankly descriptive, there would be little to criticize and much to praise, but this volume contains fully as much of chemical theory as the average teacher would consider it desirable to introduce in a single course. However, the laws and theories with which the reader of Kahlenberg's book will become familiar are chiefly limited to those which had been accepted a generation or more ago.

It was to be expected from one holding Professor Kahlenberg's pronounced views that the great modern developments in the study of solutions, especially of aqueous solutions of electrolytes, would receive but scant attention, but other great advances in chemical theory suffer from an equal neglect. The important ideas of heterogeneous equilibrium introduced by Willard Gibbs, which have been brought into simple pedagogic form by various teachers, notably by Ostwald, are not only ignored, but statements are made which flagrantly violate all phase-rule doctrine. The student can not fail to acquire fundamentally erroneous conceptions from such a paragraph as the following:

> Suppose a block of ice and one of common salt be placed in contact with each other; we note that the salt and ice gradually disappear, forming a brine. Evidently the brine has quite different properties from those of either the salt or the ice. Moreover, there was a marked change of temperature, in this case a cooling effect, as the salt and ice acted on each other. Furthermore, a contraction ensued, for the volume of the brine is less than the sum of the volumes of the blocks of ice and salt. Again, as a block of ice and one of paraffine, or one of salt and one of paraffine, for example, do not act on each other at all when brought into contact, it is clear that the action between ice and salt takes place because of the specific nature of the substances. Furthermore, it has been found that below $-22°$ C. ice and common salt no longer act on each other, just as iron and sulphur do not act on each other at ordinary temperatures. Raise the temperature sufficiently in each case, and at a certain definite point action begins.

In this paragraph the author shows also his attitude towards the important subject of reaction velocity. His comparison of the eutectic point of salt and water with the "definite point" at which sulphur and iron begin to react might be regarded as a mere slip of the pen were it not for the fact that similar ideas are advanced in the discussion of ignition points and kindred phenomena. One of the most serious fallacies concerning reaction velocity is not only affirmed but italicized on page 23.

> The rate with which a chemical reaction proceeds is proportional to the chemical affinity that comes into play.

If this were the truth we may be sure that none of us would be alive to announce it, for the affinity of our tissues for the oxygen of the air is enormous compared with that which comes into play in the majority of vital processes.

Other instances of too much theory might be cited. For example, the statements concerning the nascent state and the mechanism of oxidation and reduction processes are, to say the least, unproven. In discussing inorganic compounds frequent use is made of graphical formulæ of very questionable character. Mention is nowhere made of the simple gas laws, but an amazing polemic chapter is devoted to theories of solution and osmotic pressure.

The principle of mass action is given friendly though somewhat scant discussion. Owing to the author's unwillingness to adopt the ionic view, he has been unable to apply

this principle to the large number of phenomena in aqueous solutions which so well illustrate the laws of chemical equilibrium.

The student who depends upon this textbook may acquire a large number of useful chemical facts. He will be attracted by the lucidity and stimulated by the enthusiasm of the author, but he will nevertheless be seriously handicapped when in any field of chemical endeavor he enters into competition with men who are trained in the use of all the tools of modern chemistry. GILBERT N. LEWIS

MASSACHUSETTS INSTITUTE OF
TECHNOLOGY, BOSTON, MASS.,
January 20, 1910

Iagttagelser over Entoparasitiske Muscidelarver hos Anthropoder. Af I. C. NIELSEN. Copenhagen. 1909. Entomologiske Meddelelser, R. 2, Bd. 4 (1909), with 4 plates.

THE above paper consists of 110 pages in Danish of investigations of muscid-larvæ entoparasitic on arthropods, exclusive of careful explanations in both English and Danish of the plates and over five pages in English giving a summary of the more important results announced. It shows much painstaking work, and the author is to be highly commended on the very valuable results obtained.

After reviewing the greater part of the literature, eight species are treated in detail, descriptions and figures being given of the maggot stages and puparia, to which are added many data on host relations. The one great feature of the work is the establishing of definite characters in the pharyngeal skeleton of the eight species studied, whereby the maggot stages can be accurately determined. It is reasonable to suppose that the characters given by the author will hold good through a large part of the superfamily Muscoidea. Excellent figures are given of the pharyngeal skeleton in its different stages, and the author is undoubtedly correct in assuming that there are but three maggot stages in the majority of the Muscoidea. Some exceptions to this rule may yet be found, though it must be admitted that the probability of such is remote. Investigations carried on by the bureau of entomology at the gipsy moth parasite laboratory in Massachusetts indicate that much further study of the subject is needed.

The spiracles of the maggot, both anterior and posterior, have been carefully studied and figured by the author. The determinations of the eight species above mentioned were made with the aid of Mr. H. Kramer, the German specialist in Tachinidæ. I can only say that two of them, *Tachina larvarum* Linn. and *Carcelia gnava* Meig., are not the species handled by us under those names at the laboratory, and we have the authority of Drs. Kertesz and Handlirsch for our determinations. Nielsen's *larvarum* deposits maggots, while ours deposits eggs. As further evidence that we are right, we know that the American and Japanese species of *Tachina* deposit eggs. The anal stigmata of the puparia of our *larvarum* and *gnava* differ conspicuously from those figured by Nielsen under these names. These points only show the difficulty of arriving at uniform determinations in the Tachinidæ with our present knowledge; careful study and comparison of types, even of the most common species, must be made.

Another point of importance brought out in the paper is the fact that the chitinous funnel of the maggot is not an actual part of the latter's integument, but is formed to a large extent from the integument of the host. The author shows that this funnel is present in all three stages of the maggot of certain species, but we know that other species are without it in the first stage.

Doctor Nielsen is certainly mistaken in believing that *Compsilura concinnata* does not penetrate the skin of the caterpillar with its piercer at the moment of larviposition. Our investigations, including actual observation of the living flies and dissection of both flies and hosts, prove conclusively that such penetration takes place. There is a considerable group of species, both European and American, that have this habit. Mr. William R. Thompson has recently secured thorough demonstration of the fact with *concinnata* at the laboratory, thus verifying conclusions arrived at from a

study of the anatomy of the parts, supplemented by observation of the females and rearing of the species during three consecutive seasons.

A most interesting chapter is included on the economic value of Tachinidæ, in which it is shown that these flies, unaided by other parasites, have entirely wiped out considerable colonies of lepidopterous larvæ in Denmark.

It is greatly to be hoped that Dr. Nielsen, and other students as careful and painstaking as he, will carry on further investigation of the early stages of Muscoidea.

I have to thank Dr. L. O. Howard, chief of the bureau of entomology, for having an English translation of Dr. Nielsen's paper made for me. This translation was done by Mr. August Busck, and it is hoped that it can be published in the near future for the benefit of students not familiar with Danish.

C. H. T. Townsend
Gipsy Moth Parasite Laboratory

The Autobiography of Sir Henry Morton Stanley, G.C.B. Edited by his wife, Dorothy Stanley. Pp. xvii + 538. Sixteen photogravures and a map. Boston and New York, Houghton Mifflin Company. 1909. $5 net.

One of the greatest of modern geographers has called Henry M. Stanley the Bismarck of Africa. This was his due because of the great part he took in the solution of the many difficult problems of that continent.

The son of James Rowland, born in 1841, at Denbigh, in Wales, his early life was a succession of serious and discouraging struggles. In fact, nearly his whole life was marked by this struggle with his fellow men. Even after success had crowned him, there were always to be found those who not only doubted and opposed him, but did so to the extreme of malice.

From the time when he was cast off by his own people he may have been the child of fortune, but it was always hard to realize that such was the case; perhaps this early buffeting was the means of developing that self-reliance which was his marked characteristic through life. Neglected by his family, his early training in the poor-house certainly can not be considered as the most favorable condition for beginning a career.

The first chapters of this volume were prepared by Stanley himself, the latter portion of the work, however, is the kindly work of his talented wife, who has filled in with marked skill the blanks in his rather fragmentary journals by abstracts from his publications.

One is constantly struck during the perusal of the first part of the book by the intensely devout attitude of Stanley's mind, and his sincerity and singleness of purpose. His mental activity was curiously in contrast with his surroundings, and he was most fortunate in his early contact with Mr. Stanley, the man to whom he owed most of his serious convictions as well as his name. Would that there were more men capable and willing to throw such helpful and sturdy influences for good about the needy youth of to-day; whether it would be accepted by them or not is, of course, an open question. Stanley accepted them, however, and prospered under this guidance.

Thrown again upon his own resources by the death of his best friend, he soon became a wanderer, serving in the southern army, later a prisoner of war, then in the northern navy. At the close of the war his career as correspondent began, and he traveled extensively, inspiring confidence in his energy and capability until the New York *Herald* opened the door to his future work.

Of this work the estimate of the great Petermann, was "that he had done more than all the scientific travelers in Africa for eighty years previous, more than the Arabians for a thousand years, and that he had no equal among the 'discoverers' of the earth." This was high praise, but the physical exertions which won these words and brought him home a gray-haired man did not dampen his zeal, and when the time came to finish the work of Livingstone, he was ready for the task.

Stanley undoubtedly lived ahead of his time, but time has caught up with him, and the real

estimate of the man's work which has recently been formed by the calmer study of the unprejudiced, will only be helped by the appearance of this thoroughly good work. It is all that an autobiography should be. There is no self-laudation, no posing for effect, and no fulsome praise.

In an ascending scale we follow him through Turkey, the Levant and Abyssinia. During these campaigns he became famous for the accuracy of his work; and his energy in getting it to his publishers was so great that some of his competitors seemed inclined to doubt its authenticity until the more tardy reports verified his statements. In the following years, during the search for Livingstone, the war in Ashanti land and the search for Emin Bey, the description of the terrible difficulties encountered were undoubtedly the cause of the disbelief so frequently expressed with regard to his results. Stanley was not a scientific man, but his keen observation of facts and his conscientious performance of duty must over-balance many defects in this line. The pioneer work of the first man traveling along these lines of greatest resistance must have been savage work indeed, and demanded every ounce of vitality of the most capable explorer of his day, if not of any time, and the wonder is that so few mistakes were made.

Immediately upon his return to Europe he sought to make his work of practical value, and here again he encountered the wildest sort of antagonism. His success and his after life are matters of history and this volume records them in a most pleasant and readable manner.

WILLIAM LIBBEY

PROGRESS OF PALEONTOLOGICAL RESEARCH BY THE CARNEGIE INSTITUTE

GENEROUSLY supported by Mr. Andrew Carnegie, whose interest in paleontological research is well known, the Carnegie Museum of Pittsburgh has during the past year made many forward strides. The work of extricating from the matrix some of the skulls of the mammalia found in the summer of 1908 in the Uinta Basin by Mr. Earl Douglass was diligently prosecuted during the early part of 1909, and Mr. Douglass has published in the *Annals of the Carnegie Museum* a brief account of three new Titanotheres from the Upper Eocene. These three species represent only a few of the large number of interesting forms recovered by Mr. Douglass during the expedition of 1908. A number of fossil turtles apparently representing an equal number of species were also recovered from various levels. These have been partially prepared for study and will be submitted for description to a specialist in this group. The nearly perfect skeleton of *Moropus elatus* recovered during the explorations made in western Nebraska during the years 1906 to 1908 has been freed from the matrix and prepared for mounting. A monographic paper giving an account of the osteology of the animal is in course of preparation by the Curator of Vertebrate Paleontology. Nearly twenty skeletons, some of them absolutely complete and others approximately complete, belonging to two species of the cameloid genus *Stenomylus,* were recovered in 1908 and 1909 by Mr. O. A. Peterson. Several of these skeletons have been worked out from the matrix and two of them have been prepared as slab-mounts and are now on exhibition in the museum. A singularly perfect skeleton of a carnivore, revealing features common to the Canidæ and the Felidæ, and not distantly related to *Daphœnus felinus* Scott, has been extricated from the matrix and mounted for exhibition. A paper upon this specimen is in course of preparation by Mr. O. A. Peterson.

Mr. Earl Douglass since June has been busy making collections in various geological formations in Utah. In August he discovered three dinosaurs with the skeletons apparently completely articulated. Under the direction of the curator of paleontology he is spending the winter in Utah engaged in carrying forward the work of taking up the remains of these colossal animals. Mr. Douglass's camp is located at a considerable elevation, but he has, so far as possible, forti-

fied himself against the cold winter, and with his wife to supervise the domestic arrangements in camp, and three laborers to aid him, he is endeavoring to rapidly extricate the skeletons from the hard sandstone in which they are imbedded. He writes enthusiastically of his work, and in a recent letter says, "We have found what paleontologists have been searching for for the past forty or fifty years, skeletons of sauropod dinosaurs of huge size, apparently absolutely complete, every vertebra in position, and even the ribs in place—not removed more in any instance than two or three inches from the point where they articulate with the facets of the vertebræ." Every precaution is being taken to recover these specimens as they have been found. A photographic record is being kept of the position of every bone, and it is hoped that when the great undertaking is completed a very important addition will have been made to our knowledge of the osteology of the sauropod Dinosauria. One of the interesting features in this connection is the discovery of the sternal ribs, which never have hitherto been found in position in connection with the Sauropoda.

Dr. Percy E. Raymond has been during the past year carrying on extensive researches in the region of Pittsburgh, and has made valuable and interesting observations upon the strata of western Pennsylvania, upon which he will shortly publish, showing the existence of extensive marine faunæ at points where such deposits were hitherto not known to exist. He has also been successful in discovering some new species of invertebrates, as well as the remains of some vertebrates. His studies are calculated to throw great light upon the formations of the region, which have hitherto been only superficially examined.

Two replicas of the skeletons of *Diplodocus carnegiei* were prepared and in the fall of the year were presented, one to the Emperor of Austria, the other to the King of Italy. The first specimen is located in the Imperial Museum at Vienna, the second in the Museum of the Istituto Geologico at Bologna. These replicas were made at the expense of Mr. Andrew Carnegie and presented on his behalf to the Emperor and the King by Dr. W. J. Holland, who, with his assistant, Mr. Coggeshall, set them up. Dr. Holland was personally received by the Emperor of Austria, who conferred upon him the cross of an Officer of the Order of Francis Joseph, and conferred upon Mr. Coggeshall the cross of the Order of Merit, surmounted with the crown. The King of Italy has conferred upon Dr. Holland the cross of Commander of the Crown of Italy, and upon Mr. Coggeshall the cross of Chevalier of the same order. In recognition of Mr. Carnegie's generosity the authorities of the city of Bologna have sent to the library of the Carnegie Museum a complete set of the writings of Aldrovandi, in thirteen volumes in the original binding. The set is singularly beautiful and well preserved. The Istituto Geologico at Bologna has presented to the Carnegie Museum a series of beautiful specimens of the fossil fishes of Monte Bolca, which are being prepared for exhibition.

One of the interesting accessions to the paleontological collections of the Museum during the past year has been an enormous tusk of *Elephas columbi* Falconer, found on the banks of the Allegheny River in the suburbs of Pittsburgh. It was washed out during a freshet. It is nearly nine feet in length.

During the year a beautifully mounted skeleton of *Portheus molossus* Cope, fifteen feet in length, the most perfect in existence in any museum, has been mounted and placed upon the walls.

The vertebrate material obtained and accessed for the museum during the past twelve months is extensive, aggregating many hundreds of numbers, and the invertebrate material is even more extensive.

* * * *

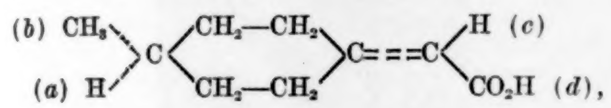
OPTICALLY ACTIVE SUBSTANCES CONTAINING NO ASYMMETRIC ATOM

The statement is frequently made that optical activity is due to the presence in the

molecule of an asymmetric atom—of carbon, nitrogen, sulphur, selenium, tin or silicon. In this form the statement is quite incorrect. As was shown by van't Hoff and Le Bel years ago, the optical activity originates in the enantiomorphous configuration of the molecule, which is conveniently recognized by the identification of a particular atom in the molecule as being asymmetric.

Experimental confirmation of van't Hoff and Le Bel's views has been recently furnished by Professors W. H. Perkin, W. J. Pope and O. Wallach[1] in an extremely valuable and lucid paper which they have contributed to the *Journal of the Chemical Society* (London).

In 1906, Perkin and Pope synthesized 1-methylcyclohexylidene-4-acetic acid,



which contains no asymmetric carbon atom. At first some doubt was expressed as to whether the acid did actually conform to the formula given, but subsequent work has amply confirmed its constitution and it has now been possible to resolve the acid into a dextro- and a lævorotatory modification, by repeated fractional crystallization of its brucine salt.

The racemic acid melts at 66°, the optically active acids melt at 52.5–53°; in absolute alcohol the specific rotatory power $[\alpha]_D$, is 81.4° and —81.1°, for the *d*- and *l*-acid, respectively. When mixed these acids regenerate the racemic acid of higher melting point.

Referring again to the formula given above, if the linkages represented by unbroken lines are supposed to occupy the plane of the paper and if those represented by broken lines lie in a plane perpendicular to the first, it will be observed that the plane which contains the continuous line bonds is not a plane of symmetry of the solid configuration, because the groups marked (*a*) and (*b*) are different. Similarly, the vertical plane mentioned above is also not a plane of symmetry, because the groups (*c*) and (*d*) are of different composition. In short, even when the usual tetrahedral symmetrical configuration is attributed to methane derivatives, the relatively simple acid formulated above is found to possess neither planes, axes nor a center of symmetry, and it is this which determines the enantiomorphism of its configuration.

The original paper will richly repay perusal; it is written in the clear and interesting manner characteristic of Messrs. Perkin and Pope's communications, and it contains a most instructive account of the great experimental difficulties which had to be overcome before this most important work could be brought to a successful issue.

J. BISHOP TINGLE

MCMASTER UNIVERSITY,
TORONTA, CANADA

[1] *Jour. Chem. Soc.*, 95, 1789, 1909.

INCOMES OF COLLEGE GRADUATES TEN YEARS AFTER GRADUATION

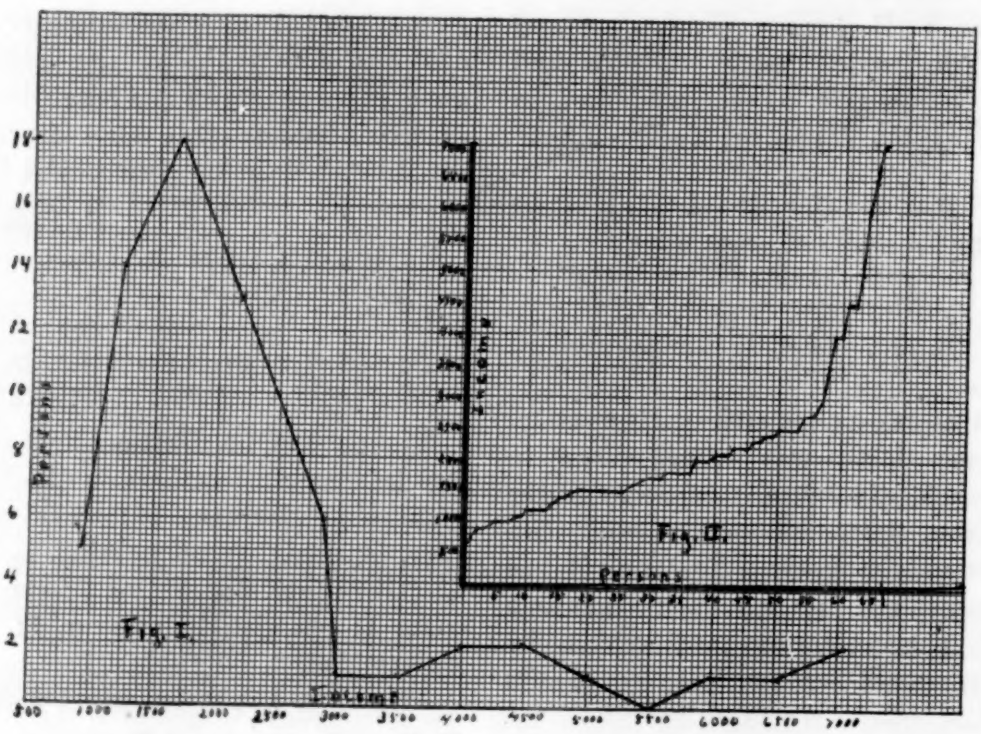
THE class of '99, Dartmouth College, has one hundred living members in the following occupations: Business, 25; teaching, 23; medicine, 14; law, 13; engineering, 10; journalism, 2; railroading, 2; farming 2; study, 2; clergyman, 1; chemist, 1; mining, 1; librarian, 1; unclassified, 3.

The class might be called average. Some were poor, and some were able to live comfortably in college, but every one has had to make his own way in his profession. At the decennial reunion last June, and by mail shortly afterwards, reports were received from sixty-seven of the men stating their incomes for the preceding year. The thirty-three from whom no facts were received are probably getting less income than the average of the class, but I do not think they would lower the average greatly.

The results show an income considerably higher than was thought by those whom I have consulted as to the probable income.

Looking at the plots we see that five men get less than $1,000, with an average of $832; fourteen men from $1,000 to $1,500, with an average of $1,209; eighteen from $1,500 to $2,000, with an average of $1,689; thirteen

from \$2,000 to \$2,500, with an average of \$2,178.60; six from \$2,500 to \$3,000, with an average of \$2,616; and one or two in each of the next five hundred dollar groups, to one man who got \$7,000. The average income for the class was \$2,097.25. The average for the fifty-six who got less than \$3,000, *i. e.*, 83 per cent. of those who reported, is \$1,705.70. Forty men are below the average of the sixty-seven who reported.



In Fig. 1 the number of persons in each five-hundred-dollar group is shown at the point of average income. In Fig. 2 we have the income of each individual.

The commercial value of a college education is often discussed, and it would be a matter of interest if a considerable number of statistics of this sort could be secured.

HERBERT ADOLPHUS MILLER
OLIVET COLLEGE

SOCIETIES AND ACADEMIES

THE MICROSCOPICAL SOCIETY OF ILLINOIS

THE regular October meeting of the State Microscopical Society of Illinois was held on October 8, after the usual summer intermission, at the club room, Wesslick's Restaurant, Chicago.

Francis T. Harmon gave an address on "Photomicrography," and exhibited the specially constructed apparatus he used in taking the exquisite photographs which have given him a wide celebrity. A number of these were shown, both in ordinary finish and in natural-color photographs.

At the November meeting in the same place President Marshall D. Ewell described his lately constructed instrument, the micro-colorimeter, for comparing and testing exact and minute differences of color and tint.

Harold D. Skelton exhibited and described the new Bausch and Lomb balopticon for projection, and its capabilities were tested in the projection on the screen of a number of lantern slides, opaque pictures and diagrams, and a variety of microscopic slides or objects shown by various members present.

Dr. S. V. Clevenger read a paper on "Comets and Star-dust," with illustrations by the balopticon.

At the December meeting, held Friday, December 10, Wm. F. Herzberg gave an address on "Crystallography," and the methods of mounting and study of crystals. Most of the evening was spent in study under the microscope of the objects exhibited by the members present.

It was resolved to give another soirée similar to the very successful one of last year, and a committee of arrangements was appointed.

ALBERT MCCALLA,
Secretary